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ABSTRACT

The programs developed by the U.S. Department of Energy and the National Laboratories to lure an untapped well of students into scientific fields and to increase the number of qualified scientists coming into the research environment are described. The witnesses of this hearing are from the Department of Energy and the National Labs; the outside organizations who will develop and administer the programs; teachers who face a lack of resources, materials, and interest on the part of students; other educators; and students who are currently participating in Department of Energy and Oak Ridge National Laboratory Programs. Witnesses include: (1) Alvin W. Trivelpiece, director, Oak Ridge National Laboratory, Oak Ridge, Tennessee; (2) Robert W. Springer, director, Division of Educational Programs, Argonne National Laboratories, Argonne, Illinois; (3) Manuel Perry, human resources planning and development, Lawrence Livermore National Laboratory, Livermore, California; (4) William F. Willis, chief operating officer, Tennessee Valley Authority, Chattanooga, Tennessee; (5) Marjorie G. Bardeen, program director, Friends of Fermilab, Fermi National Accelerator Laboratory, Batavia, Illinois; (6) Jon M. Veigel, president, Oak Ridge Associated Universities, Oak Ridge, Tennessee; (7) Lee L. Reidinger, director, the Science Alliance and Professor of Physics, University of Tennessee, Knoxville, Tennessee; (8) Bernard W. Benson, Tennessee Academy of Sciences, director of the Center for Environmental, Energy, and Science Education, University of Tennessee, Chattanooga, Tennessee; (9) Ronald B. Cox, dean, School of Engineering, University of Tennessee, Chattanooga, Tennessee; (10) Vivian Prentice Brown, science teacher, Model High School, Rome, Georgia; (11) Robert Rogers, Hamilton County Department of Education, Chattanooga, Tennessee; (12) Geraldine T. Farmer, science consultant, Tennessee Department of Education, Nashville, Tennessee; (13) Jennifer A. Ethridge, student, Roanoke College, Salem, Virginia; (14) Teresa E. Kowalski, student, California University of Pennsylvania; and (15) Miguel Rodriguez-Velez, student, University of Puerto Rico. (KR)

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ROLE OF NATIONAL LABORATORIES IN SCIENCE, MATHEMATICS AND ENGINEERING EDUCATION

ED342628

HEARING

BEFORE THE

SUBCOMMITTEE ON
ENERGY RESEARCH AND DEVELOPMENT

OF THE

COMMITTEE ON
SCIENCE, SPACE, AND TECHNOLOGY
HOUSE OF REPRESENTATIVES

ONE HUNDRED FIRST CONGRESS

FIRST SESSION

MAY 15, 1989

[No. 90]

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ROLE OF NATIONAL LABORATORIES IN SCIENCE, MATHEMATICS AND ENGINEERING EDUCATION

MONDAY, MAY 15, 1989

House of Representatives,
Committee on Science, Space, and Technology,
Subcommittee on Energy Research and Development,
Washington, DC.

The Subcommittee met, pursuant to notice at 10:13 a.m., at the Hamilton County Bicentennial Public Library, Chattanooga, Tennessee, Honorable Marilyn Lloyd (Chairman of the Subcommittee) presiding.

OPENING STATEMENT OF HON. MARILYN LLOYD, CHAIRMAN, SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Ms. Lloyd. The Subcommittee will come to order. Good morning, ladies and gentlemen, thank you for being here.

Today we stand on the brink of a crisis. As our technological advancements and developments occur faster and faster, we as a society struggle to come to terms with the moral and policy implications which arise from our technologies. But while technology advances, we are also experiencing repeated serious declines in enrollments in science, mathematics and engineering fields. Students are choosing other careers. This trend threatens the entire scientific community. The students today are the scientists of tomorrow.

We have all seen how fast technology has advanced, and the prospect of having a shortage of qualified scientists coming into the research environment is frightening. Science academies and associations, educators, researchers and yes, even Congress, are all examining this issue. Some are looking for solutions for their particular disciplines and others are looking for broader answers.

The Department of Energy and the National Laboratories recognized this problem, saw its potential impact on their activities and set about to take action. They recognized too that there is a large, untapped well of students, women and minorities, and designed programs and criteria to lure these students into scientific fields.

The DOE Lab and personnel and other people created programs for all grade levels, as well as undergraduate programs. But another question remained. How do we reach the most kids with the limited resources. One way is to reach the teachers. The National Laboratories then created summer programs for science teachers of all levels to give them practical laboratory experience and new ways to present information. In addition to long term professional support for the teachers, some of these programs also provide teachers with additional course materials for use in classrooms.

Today, we are going to hear about these programs from the Department of Energy, from Labs, from the outside organizations who will develop and administer them, from teachers who face a lack of resources and materials as well as a lack of interest on the part of students, from other educators and from students who are currently participating in Department of Energy and Oak Ridge National Laboratory programs.

This Subcommittee is interested in learning the goals of the various programs and their effectiveness. We are eager for recommendations and suggestions for improving and expanding this important role of the National Laboratories and how we, as legislators, might best assist their efforts.

I want to welcome everyone here today. I think this promises to be a very interesting day, a very profitable one, but before we do call our first witnesses, I want to recognize my colleague, Congressman Steve Schiff from New Mexico, for his opening remarks. And I must tell you that this is one of the hardest working members on my Subcommittee. When we went to Illinois for field hearings he was there, he's going to go out west with us for some more field hearings and I wish everybody on the Committee worked as hard as you do, Steve, and I want to give you a real big Tennessee welcome today.

Mr. SCHIFF. Thank you very much. First to be official, Madam Chair, I have some prepared remarks that frankly echo your own, which I would ask be incorporated into the record. They are already in the notebook.

Ms. LLOYD. Without objection.

[The prepared opening statement of Mr. Schiff follows:]

OPENING STATEMENT
HON. STEVEN SCHIFF
HEARING TO EXAMINE ROLE OF NATIONAL LABORATORIES IN SCIENCE, MATHEMATICS AND ENGINEERING EDUCATION
MAY 14, 1989

Madam Chairman, I am pleased to join you this morning to welcome our distinguished witnesses and hear their thoughts on the role of our National Laboratories in Science Education. This Subcommittee is always seeking ways to provide incentive for college students to pursue careers in science and engineering, and to improve the quality of elementary and secondary instruction in science and mathematics.

It is clear that we need to continue our support in these areas. Last year, the National Science Foundation reported that less than 20% of high school sophomore were interested in careers in natural sciences and engineering. It is also true that only 5% of the students who go to college receive baccalaureate degrees in science or engineering; that less than a third of them continue their training; and that only a quarter of those who do eventually receive their doctorates. With this type of alarming statistics, it is indeed timely for this Subcommittee to receive ideas and recommendations on how we can improve the quality of science education and the effectiveness of these programs in our national laboratories.

OUR NATIONAL LABORATORIES HAVE BEEN DOING A MARVELOUS JOB OF EDUCATING AND TRAINING SCIENCE TEACHERS AS WELL AS STUDENTS. THIS SUBCOMMITTEE, UNDER YOUR FEARLESS LEADERSHIP, MADAM CHAIRMAN, HAS ALSO DEMONSTRATED OUR SUPPORT THROUGH AUTHORIZING ADDITIONAL FUNDING FOR BASIC ENERGY SCIENCES AND UNIVERSITY RESEARCH SUPPORT YEAR AFTER YEAR. WITH CONGRESSIONAL FUNDING, OUR NATIONAL LABORATORIES HAVE BEEN ABLE TO PROVIDE THE TRAINING GROUND TO UPGRADE THE QUALITY OF OUR SCIENCE TEACHERS, AND ALLOW STUDENTS TO CONDUCT THEIR RESEARCH IN TOP-NOTCH LABORATORIES FOR THEIR THESES AND DISSERTATIONS.

THIS NATION'S SCIENCE AND TECHNOLOGY EFFORTS ULTIMATELY DEPEND ON AN ADEQUATE SUPPLY OF HIGHLY-TRAINED AND EDUCATED PEOPLE. WE MUST CONTINUE TO ATTRACT MORE STUDENTS TO THE STUDY OF SCIENCE, ENGINEERING, AND MATHEMATICS, THEREBY STRENGTHENING THE LEADERSHIP OF THE UNITED STATES IN THESE AREAS. WITH THAT SAID, I LOOK FORWARD TO HEARING FROM OUR WITNESSES TODAY.

OPENING STATEMENT OF HON. STEVEN H. SCHIFF, MEMBER, SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

Mr. SCHIFF. I just want to take one moment to say that I am the newest member of the Subcommittee on Energy Research and Development. I was elected to the United States Congress last November, so this is my first year. I solicited an appointment on the Science, Space and Technology Committee and on the Energy Research and Development Subcommittee for two reasons. First of all, we all represent districts, and in our district as in this area, you have Oak Ridge National Laboratory here, it is an important part of the area—I understand it is not precisely in the district, but it is important in the area. I have Sandia National Laboratory in my district and Los Alamos National Laboratory not very far away. And therefore, this is of interest to the community.

But even more important than that, I think these facilities are important to the Nation. I do believe that the ultimate future of our Nation lies in Science and Technology. I think that if we are going to be successful, that must start with the education of young people and the direction of young people towards careers in Science and Technology. And that is why I am looking very much forward to this particular hearing.

One last word I would like to add because it is deserving since I am in Mrs. Lloyd's district. As you are probably aware, Mrs. Lloyd is a Democrat and I am a Republican and we are both call it as we see it voters I have noticed on the House floor. But nevertheless, we do sit on opposite sides of the aisle. What I think you should be aware of is that on the Energy Research and Development Subcommittee, there is no such thing as Republican and Democrat. There may be a place somewhere for differences along party lines perhaps, that has never shown itself in our work. All members are treated equally and all of their ideas and thoughts are given equal consideration, and I just wanted to say I personally very, very much appreciate that.

Ms. LLOYD. Thank you. It is a delight to work with you and to have you here.

Before we begin some hearings, I think maybe we should establish some ground rules. We do have a lot of witnesses today and we do want to finish by four o'clock. I think the library says we have to get out about four o'clock and we want to—we appreciate the library allowing us to use their facilities and we want to abide by their rules as well. So we are going to ask that you limit your oral presentations. If you can hold them to about ten minutes it would be appreciated. And we do have your prepared statements in their entirety, they will be made a part of this Congressional hearing.

Certainly our first witness today is no stranger to this subcommittee, she is a good friend of ours, she is a great person. She is representing the Department of Energy, Toni Joseph, and she is a Director of the Office of Field Operations Management, a very talented lady. Ms. Joseph oversees both the University programs and the lab management programs, which includes the internships and the fellowships. We do welcome you to Chattanooga. Your entire statement will be made a part of the record, and Toni, please proceed.

STATEMENT OF ANTOINETTE GRAYSON JOSEPH, DIRECTOR OF FIELD OPERATIONS MANAGEMENT, OFFICE OF ENERGY RESEARCH, U.S. DEPARTMENT OF ENERGY

Ms. **Joseph**. Thank you, Madam Chairman and members of the Committee.

I do appreciate the opportunity to appear before the Subcommittee to discuss the Department of Energy's science education programs. Secretary Watkins sends you his regards. As you know, he has been personally involved in the area of training America's young people for some time. In his testimony before Congress, he stated his personal interest in and his commitment to making significantly greater progress in improving science education, especially at the precollege level and especially for minorities and women.

We in the Office of Energy Research in DOE are committed to our science education programs, which are a very important part of the Department's overall mission. Because of our unique laboratory resources, the Department has the ability to help nurture young scientific talent in this country in a very special way. We are also especially proud of the fine work being done here in Tennessee at Oak Ridge National Laboratory and at the Oak Ridge Associated Universities. As you will hear from other witnesses today, they have some of the best programs in the Department's science education effort.

Based on the fan mail we receive about the Department's science education programs, both from students and from teacher participants, the Laboratories are "awesome", the science is exciting and the people are wonderful. We are proud of our program and the people in the field who carry them out.

Under the new Administration, we have a renewed sense of purpose and enthusiasm inspired by a Secretary who is dedicated to making a difference in science education. The Secretary has already asked us to re-examine our current programs in science education to see what changes should be made to even more effectively involve DOE in the national effort to strengthen the Nation's science education system.

I would like to comment only very briefly on some of the regional outreach and volunteer activities going on across the country, since you have a number of witnesses today who are directly involved in these outstanding efforts. As you requested, I will also very briefly summarize the current programs sponsored by DOE in precollege and university-level science education. All of these programs make effective use of the unique resources and capabilities of the Department's National Laboratories, both the energy research laboratories and the defense laboratories, and the affiliated university consortia. They have as a major focus providing opportunities for hands-on research experiences.

DOE has had a long tradition of concern and support for science education, going back to the very earliest days of the Atomic Energy Commission.

The focus of DOE support has traditionally been at the graduate and postdoctoral levels through the funding of university research. This includes support for participation of 3,500 to 4,000 graduate students in DOE research projects each year. In recent years, increased funding has also been provided for precollege and undergraduate-level science education programs.

The Department is acutely aware of the problems that Congresswoman Lloyd mentioned, and that continued progress in R&D strongly depends on the quality and the quantity of human resources that are available in the fields of science, mathematics and engineering.

The current demographic trends portend a declining college enrollment in areas that are critical to national competitiveness and to the DOE's mission. A concomitant trend shows a decline in the quality of science education in our schools and on U.S. student scores on international science achievement tests. Recognition of these problems, or as the Secretary calls them, challenges, has led the Department to broaden and to increase its efforts.

The DOE National Laboratories and research contractors are essential to the Department's programs and to its support for science education. The activities of these laboratories already cover a spectrum of science education programs from elementary school to postdoctoral research. This spectrum includes outreach to youngsters to stimulate and nurture interest in science, special programs at the upper precollege level to give students and their teachers a taste of "live science" and intensive hands-on research experiences for university students and faculty.

DOE support for science education includes a vast range of volunteer and informal assistance. Thousands of DOE-supported scientists and engineers volunteer to assist local schools and colleges in every region across the country. Over 200 informal volunteer-based science education activities, including in-house tours, visits and demonstrations at the laboratories for elementary school students and teachers, direct classroom instruction and assistance at local schools, science fair sponsorship and judging, teacher workshops, teacher institutes, research participation programs, and a number of special events for things such as the National Science and Technology Week celebration, characterize the activities of the Laboratories.

Oak Ridge has outstanding efforts in these areas with inspiring acronyms like CHALLENGE, PALS, STRIVE and special targeted programs in support of the historically black colleges and universities. I am sure you will hear about all of them in detail.

One of the unique efforts at Oak Ridge has an unpronounceable acronym. It is the Ecological and Physical Sciences Study Center, or EPSSC, which reaches students and teachers from elementary to junior high and high school, involving them in hands-on learning experiences in environmental science. I understand that over 9,000 students and teachers from eight East Tennessee counties participated in the Center's activities this year.

Other outreach activities include DOE participation in the annual International Science and Engineering Fair, and the President's Adopt-A-School program. Saturday Morning Physics has been duplicated throughout laboratories and universities thanks to the initiatives of Leon Lederman at Fermi Laboratory. The Department also provides excess DOE-owned laboratory research equipment to universities, colleges and other non-profit institutions.

DOE laboratories also provide a broad array of technical assistance and support, especially to small regional colleges and universities.

The Department's current precollege science education programs focus on encouraging more young people to enter and to stay in the science and engineering manpower pipeline, and on strengthening the capabilities of precollege science teachers, which you expressed as one of the most important parts of our program, and also one of the newest, as well as on strengthening the capabilities of those teachers to motivate and to excite young students about the opportunities and challenges of scientific and technical research.

The prefreshman engineering program provides support for summer enrichment workshops on engineering and related subjects for women and minority seventh to tenth grade students. As the demographic data tells us, these will be by far, the majority of entrants into the new work force in the year 2000. Over 2,000 students annually participate in PREP projects located at campuses across the country, which are jointly funded by the private sector.

A high school student research apprenticeship program is carried out at many DOE National Laboratories and is designed to motivate freshman and sophomore minority high school students to pursue science or technical careers.

The DOE high school science student honors research program provides selected science students an opportunity to participate in hands-on research at DOE laboratories. During the summer of 1989, there will be seven honors programs with a total of 374 high school students. The one at Oak Ridge will concentrate on environmental research and since Al Trivelpiece was one of the founders of the DOE program, I am sure that it will continue to be a big success at Oak Ridge.

Under a program begun just last year, high school science and math teachers are now nominated by each State to participate in a special eight-week summer research program at selected DOE National Laboratories.

Programs in support of undergraduate science education include the core undergraduate student summer research participation, the lab co-op program, the new science and engineering research semester for undergraduates and faculty and student research teams. They reach—these programs reach over 1,400 undergraduates each year.

This long list of programs may give the impression of completely separate activities, but, in fact, with the recent establishment of science education centers at appropriate DOE laboratories, these activities are able to be integrated into a focused effort that supports the broad range of science education aimed at increasing and improving future manpower resources in energy related areas. It still permits, and, in fact it improves, laboratory flexibility to include special regional, local and unique efforts reflecting the capabilities and opportunities of the individual laboratories. We are very proud of what the Department has accomplished through its national research laboratories in science education.

As I said earlier, we are in the process of re-evaluating our current science education programs and I look forward to hearing from you and from the participants at this hearing about ways that the Department can do an even better job in the future to meet the Nation's challenges in science education.

Thank you very much.

[The prepared statement of Ms. Joseph follows:]

STATEMENT OF

ANTIONETTE GRAYSON JOSEPH

DIRECTOR OF FIELD OPERATIONS MANAGEMENT
OFFICE OF ENERGY RESEARCH
U.S. DEPARTMENT OF ENERGY

BEFORE THE

HOUSE SCIENCE, SPACE, AND TECHNOLOGY
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT

FIELD HEARING IN

CHATTANOOGA, TENNESSEE

MAY 15, 1989

Madam Chairman and Members of the Subcommittee:

Introduction

I appreciate the opportunity to appear before the Subcommittee to discuss the Department of Energy's (DOE) science education programs. Secretary Watkins sends his greetings and, as you know, the Secretary has been personally involved in the area of training America's young people for some time. In his testimony before Congress, he stated his personal interest in and commitment to making significantly greater progress in improving science education at the precollege level. The Secretary has asked us to reexamine our current programs in science education to see what changes should be made to even more effectively involve DOE in the national effort to strengthen the Nation's science education system.

I would like to comment on some of the regional outreach and volunteer activities going on across the country and summarize the current programs sponsored by DOE in precollege and university-level science education. These programs make effective use of the unique resources and capabilities of the Department's national laboratories and affiliated university consortia. They have as a major focus providing opportunities for hands-on research experiences.

History

DOE has had a long tradition of concern and support for science education going back to the very earliest days of the Atomic Energy Commission (AEC). For example, AEC was one of the first Federal agencies to support graduate research fellowships in key scientific and engineering disciplines. Many of today's scientific and technical leaders in the energy industry, the national laboratories and the university community began their research careers with graduate student support from the AEC. Many of today's leaders in the civilian and defense-related nuculear sector also received their initial training in nuclear energy through AEC-supported training programs at Oak Ridge. This includes Secretary Watkins. The AEC supported undergraduate student summer research and related faculty research beginning in the late 1950's, and initiated precollege student and teacher science education programs in 1962.

The focus of DOE support for science education has traditionally been at the graduate and postdoctoral levels. The principal means by which this is accomplished is through the support of university research which totals approximately $477 million in FY 1989. This includes support for the participation of 3500-4000 graduate students. In recent years, increased funding has also been provided for precollege and undergraduate-level science education programs.

DOE Laboratories and Science Education

The DOE national laboratories and research contractors are central to the Department's programs and to its support for science education. The potential of these laboratories to provide major assistance to precollege and university science education has only been partially realized. The DOE laboratories form a national and regional network covering a spectrum of science education programs from elementary school to postdoctoral research. This spectrum includes outreach to youngsters to stimulate and nurture interest in science, special programs at the upper precollege level to give students and their teachers a taste of "live science", and intensive research experiences for university students and faculty. There are few places in this country which can equal the range of science education opportunities and resources that are available at a major DOE national laboratory--big science, disciplinary and multidisciplinary research, individual investigator and team research, all coupled with world-class scientific facilities, equipment and technical support resources.

Outreach and Volunteerism

DOE support for science education includes both funded formal programs and a vast range of volunteer and informal assistance. Thousands of DOE-supported scientists and engineers volunteer to assist local schools and colleges in every region across the country.

In addition to the formal national DOE initiatives funded by the University Research Support Program, there is a range of informal, volunteer-based science education activities carried out by each DOE laboratory and research contractor. A recent survey indicated that there were over 200 individual precollege efforts involving thousands of teachers and students underway at 23 DOE facilities. These efforts included in-house tours, visits and demonstrations at the laboratories for elementary school students and teachers, direct classroom instruction and assistance at local schools, science fair sponsorship and judging, teacher workshops and institutes, research participation programs and a number of special events for the annual National Science and Technology Week celebration. Even retired DOE and contractor staff are resources in science education. Retirees from the DOE Idaho National Engineering Laboratory serve as resource consultants and teaching associates in local schools in Southern Idaho.

Each year DOE, along with many other Federal agencies and private companies, participates in the annual International Science and Engineering Fair. This Fair involves over 200 high school science students who have prepared exhibits on science-related research projects. DOE selects the top ten energy-related science exhibits and awards the winning students, along with their teachers, a week-long research and educational experience at a DOE national laboratory. In 1989 the student winners will spend a week at the Idaho National Engineering Laboratory learning about the many exciting technical challenges in nuclear power technology. Three years ago, the program was held at Oak

Ridge National Laboratory. Based on the legislation which established the Atomic Energy Commission, DOE has the authority to grant title to excess DOE-owned laboratory research equipment to universities, colleges and other non-profit institutions. This program over the years has served as an important source of laboratory equipment for many smaller colleges and predominantly minority institutions. The equipment is awarded on a "first-come, first-served" basis. It can be used by the receiving institution for either research or instructional purposes. Information on available equipment is provided on a monthly basis in both a printed catalog and on a dial-up computer information system.

The DOE laboratories also provide a range of technical assistance and support to small regional colleges and universities. This can range from providing laboratory scientists as guest lecturers and adjunct faculty to advising on the set-up and maintenance of research equipment and instrumentation. The Argonne National Laboratory has established a Regional Instrumentation Center where faculty and students from Midwest colleges can come to Argonne to use certain specialized instruments not normally found on many small campuses.

A central organizational focus for DOE's formal support of precollege and undergraduate science education programs is provided by the Office of Energy Research's University Research Support Program, which is administered by my office. In FY 1989 approximately $12 million will be provided through this program for precollege and undergraduate science education.

DOE Precollege Science Education Programs

The strength of DOE's precollege science education programs lies with the scientists and engineers who work for DOE in universities and at the national laboratories. Exposing students and their teachers to "live science" in a research laboratory can ignite the interest and intellectual curiosity of students and teachers. Even informal encounters with research scientists and engineers can be pivotal in stimulating young people to pursue careers in science and engineering. Therefore, the Department's current precollege science education programs focus on encouraging more young people to enter and stay in the science/engineering manpower pipeline. Equally important, it aims to strengthen the capabilities of precollege science teachers to motivate and excite young students about the opportunities and challenges of scientific and technical research. These programs are as follows:

PreFreshmen Engineering Program (PREP):

The PREP program provides support for summer enrichment workshops on engineering and related subjects for women and minority 7th-to-10th grade students. These workshops are conducted on-campus and provide the participants with pre-engineering enrichment experiences including laboratory work, field trips, career counselling and tutoring in mathematics. The overall purpose of PREP is to encourage the young participants to consider careers in engineering and related fields. Over 2000 students annually participate in PREP projects located at campuses across the country. Statistics indicate that over the years 60% of the student participants have historically enrolled in college-level engineering or science programs. Some individual PREP projects have reported that over 80% of their participants have gone on to major in engineering or science in college.

High School Student Research Apprenticeships:

The Apprenticeship program is conducted at five DOE national laboratories and is designed to motivate freshmen and sophomore high school students to pursue scientific or technical careers. The Apprenticeship program centers on providing laboratory research experiences along with counselling and tutoring. About 130 students (over 90% are women and minorities) are involved in this program each year at the participating laboratories.

DOE High School Science Student Honors Research Program:

Beginning in 1985, DOE has provided opportunities to the Nation's very best high school science students to participate in hands-on summer research at DOE laboratories. Students are selected for this prestigious Honors Research Program by the Governors of their respective States (including Puerto Rico, American Samoa and the District of Columbia). During the summer of 1989 there will be seven Honors Programs with a total of 374 students participating. Each of these Programs concentrates on a different area of science, such as: synchrotron radiation research (Brookhaven); life sciences and genetics (Lawrence Berkeley); supercomputers and computational science (Lawrence Livermore); environmental research (Oak Ridge); materials sciences including superconductivity (Argonne); particle physics (Fermilab); and marine and semi-arid ecosystems (Pacific Northwest Laboratory). All of the former participants in the Honors Program have gone on to college. Over 75% are proposing to major in science or engineering with the remainder split among law, business and medicine.

High School Science Teachers Research Associates Program:

High school science and mathematics teachers are nominated by each State to participate in a special eight week summer research program at selected DOE national laboratories. We expect 150 science teachers in the program this summer. Each teacher will serve as a participating member of a laboratory research team and will use this experience to develop supplemental materials and experiments for use in the classroom. Many of the teacher participants will also be awarded graduate-level credit by regional universities for participating in this program.

DOE Undergraduate Science Education Programs

The Department's support for undergraduate science education also is centered on providing students and faculty members with the opportunity to participate in "hands-on" research at DOE facilities. Undergraduate students are particularly important since the experience of participating in state-of-the-art scientific research directly influences their specific career choices in scientific and technical fields. Specific programs in undergraduate science education are as follows:

Undergraduate Student Summer Research Participation Program:

Each summer approximately 1100 undergraduate science and engineering students are competitively selected to spend a summer conducting research at DOE laboratories and research facilities. About half of these participants are from small, predominantly undergraduate institutions. The students work as members of laboratory research teams, often in conjunction with university faculty members. Student research assignments are carefully selected and monitored to ensure they are meaningful and at an appropriate professional level. Evaluations of this program indicate that 90% of the participants go on to receive advanced degrees in science or engineering, and that 65% of the participants indicate that their research participation experience greatly influenced their choice of career specialization.

Science and Engineering Research Semester for Undergraduates:
This program is a nationally competitive activity which provides semester-length research opportunities for junior and senior college students majoring in science, mathematics or engineering. In FY 1989 over 300 students will participate in this program from universities and colleges across the country, many of which are small non-doctoral degree institutions. Each student participates in an on-going research program at the host laboratory and learns to use sophisticated, state-of-the-art scientific equipment. This program is especially beneficial for those students considering graduate study and research.

Faculty/Student Research Teams:
DOE encourages faculty members, particularly at smaller institutions, to spend a summer or an academic year conducting research at a DOE facility along with one or more of their undergraduate students. There will be thirty faculty/student research teams at five DOE laboratories this summer. These teams are important links between DOE laboratories and individual colleges. Faculty members tend to return each summer to the laboratory to continue their

research bringing along a new group of students. Several campuses have made the faculty/student team program a major recruiting point with prospective students.

Future Expansion and Direction of DOE Science Education Programs

We are proud of what the Department has accomplished through its national research laboratories in science education. We believe we can do even more, both directly and in cooperation with the National Science Foundation and the Department of Education. As I stated at the outset of my testimony, we are in the process of reevaluating our current science education programs. We will be making recommendations to the Secretary on possible changes in order to more effectively carry out the programs he believes will most successfully utilize the Department's resources in meeting the Nation's needs in science education.

This concludes my testimony and I would be pleased to respond to your questions.

DOE/S-0065

Science and Engineering Education

July 1988

A Report of the
Energy Research Advisory Board
to the
United States Department of Energy
Washington, D.C. 20585

Energy Research Advisory Board
to the
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1000 Independence Avenue, S.W.
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JUL 29 1988

Honorable John S. Herrington
Secretary of Energy
Washington, D.C. 20585

Dear Mr. Secretary:

I am pleased to submit to you the Energy Research Advisory Board's report Science and Engineering Education. This report, approved by the Board on June 15, 1988, is a result of your request for the Board to review the activities of the Department in education in order to ensure that DOE is playing its proper role to meet its own projected manpower needs and to work closely with the other federal agencies and the private sector in the support of scientific and technical education and training.

The Board found that the Department of Energy has a continuing, critical requirement for a broad spectrum of highly educated and trained scientists, engineers, and technicians, and that DOE needs to continue and to strengthen its role in the education and training of these human resources. In this context the Board found that DOE has established a clear leadership role in graduate and postdoctoral education in many fields of science and engineering important to its primary mission in energy research and development, and that this program also makes a great contribution to other science-based, high-technology industries so vital to our economic strength, and especially to our international competitiveness.

The Board concluded that DOE's greatest contribution to science and engineering education is in its support of research in the universities, and in bringing the university professors and students into close working relationship with the DOE laboratories and energy-industry professionals. The Board felt that this effort needs to be continually updated and strengthened.

The Board also concluded that the very strength of the DOE laboratories in frontier research give them unique capabilities to conduct special programs in precollege education. These range from DOE laboratory institutes conducted in the summer for secondary school teachers and interested high-school students, to supplying literature and videos about the energy sciences to elementary and secondary schools, to participating in lectures and other programs to educate the public on science and technology issues pertinent to national and international energy options. The Board applauded these efforts. In strengthening the Department's precollege education program, the Board recommended that special emphasis be given to enhancing the knowledge, skills, understanding and science interest of science teachers at the secondary level

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and of elementary-school teachers because of the multiplier effect one good teacher can have on many students.

More can be done to strengthen the human resource pool. Continuing education and training of scientists, engineers, and technicians is one important way. Another way is special programs that encourage women and underrepresented minorities to enter and pursue careers in science and engineering. Private companies involved in energy-related businesses can also do much to support science and engineering education. For example, they can conduct in-house educational programs; donate used equipment to educational institutions; help local high schools, colleges and universities improve their energy-related teaching materials and curricula; and provide part-time employment to teachers dividing their time between precollege teaching and R&D work. The Board recommends that DOE should actively encourage such efforts.

I hope that you find this report interesting and useful. We look forward to your response. We also wish to express our thanks to the staff at the Department for their dedicated assistance and cooperation in its preparation.

Sincerely,

John H. Schoettler

John Schoettler
Chairman

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JUL 25 1988

John H. Schoettler, Chairman
Energy Research Advisory Board
U.S. Department of Energy
Washington, D.C. 20585

Dear John:

I am pleased to submit to you the report "Science and Engineering Education" developed by the Education Panel. The report reviews the Department of Energy's activities in education and makes recommendations to ensure that the Department is playing its proper role vis-a-vis other Federal agencies and the private sector.

The Panel, in public meetings, heard from senior officials within the Department of Energy and the National Laboratories, other Federal agencies, and professional societies and associations concerned with scientific and technical education in the United States. We benefited from their contributions and hope that their views are accurately reflected in this report.

I wish to thank the members of the Panel and its staff for their diligent work and assisting dedication. I hope the Department finds this report useful.

Sincerely,

Mildred Dresselhaus

Mildred Dresselhaus
Chairman, Education Panel

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ABSTRACT

The report is a result of the request by the Secretary of Energy, in February, 1987, for the Energy Research Advisory Board to review the activities of the Department of Energy in science and engineering education to ensure that DOE is playing its proper role to meet both its own project manpower needs as well as to work closely with the other federal agencies and the private sector in the support of scientific and technical education and training.

The report describes the problems the Department is likely to encounter in the next several years in meeting its demand for highly talented and skilled scientists, engineers, and technicians, and concludes that without intervention now to ensure an adequate future manpower supply, the Department is unlikely to achieve its missions in energy and defense R&D. The efforts that DOE has made over the past few years to strengthen its science education programs, especially in the undergraduate and precollege areas, are discussed and opportunities for further strengthening these programs are identified.

The report recommends that DOE continue to emphasize its educational mission primarily through support of graduate students and postdoctoral fellows through university grants and contracts which simultaneously serve the research mission of the Department. An appropriate increase in support is recommended through a targeted expansion of graduate and postdoctoral research fellowships programs in areas of greatest human resource shortages. The report suggests that the Department increase support for undergraduate research opportunities through existing programs at the DOE laboratories and as part of on-campus research grants and contracts.

At the precollege level, the report recommends that DOE target its efforts where it can realize the greatest impact, namely by providing teachers with opportunities for research participation to enhance their science backgrounds and their instructional strategies. Programs are also recommended to enhance the training of new science teachers and to provide opportunities for joint teaching and research participation careers.

The report notes that minorities and women are underrepresented in science and engineering and recommends that DOE support increased participation in science education programs at all levels, precollege through postdoctoral.

The report also recommends that DOE maintain a strong continuing education programs at its national laboratories, permit participation by local industries, and encourage private companies involved in energy-related businesses to do more to support science and engineering education.

EXECUTIVE SUMMARY

The U.S. is faced with a disturbing decline in the quality and quantity of students preparing for careers in science and engineering. Consequently, the supply of a broad spectrum of highly educated and trained scientists, engineers, and technicians to carry out the mission of the Department of Energy (DOE) in energy and defense R&D is jeopardized. To reverse this trend, the DOE has been strengthening its role in the education and training of scientific and engineering personnel. The Panel commends the DOE for developing programs ranging across all levels, from precollege through post-doctoral education. Nevertheless, the decline in available human resources in science and engineering continues and the predicted shortfall represents a serious future problem. Therefore, the DOE must strengthen its education efforts consistent with its mission, taking advantage of the unique facilities and personnel available through the national laboratories.

The DOE's greatest contribution to science and engineering education is through support of graduate and post-doctoral research by funding university-based research programs and selected fellowship programs. The DOE and its predecessor agencies have established a leadership role at this education level in many fields of science and engineering important to its primary mission in energy research and development. These graduate activities also make a great contribution to other science-based, high technology industries vital to our economic strength and our international competitiveness.

The vitality of these graduate and post-doctoral programs requires a steady stream of talented undergraduate students committed to science and engineering. Thus the Panel recognizes the importance of attracting young people at the undergraduate level so that they will pursue science and engineering graduate programs of special interest to the DOE. As a stimulus to the pursuit of scientific and technical careers, DOE, through its national laboratories, conducts a number of programs which provide undergraduate students with "hands on" research experience. These programs have proven to be an excellent vehicle for encouraging undergraduates to undertake graduate studies in science and engineering.

To increase the quality and quantity of science and engineering undergraduates, the Department also supports precollege education programs aimed at enhancing the knowledge base and general scientific literacy of all students and targeting those students who demonstrate potential and commitment for continued education in science and engineering. The strength of the Department's precollege programs lies in the DOE laboratories, staff and facilities which, by exposing students and teachers to "live science" in a laboratory setting, can ignite the intellectual curiosity of the students and revitalize the capabilities of their teachers.

The Panel believes that a healthy precollege science and mathematics education system is essential to the DOE's mission. However, because the precollege education system is huge, the DOE cannot expect and should not alone try to influence the entire system. DOE can help by working closely with industry, other federal agencies, and state and local governments to improve the system with steady, reliable and encouraging support.

This combination of programs, spanning the precollege through post-doctoral levels, encourages and sustains students' interest in pursuing science and engineering careers. To ensure a reliable supply of human resources, these programs must be initiated early in the educational experience and must include women and minority groups which have been traditionally underrpresented in science and engineering.

In recognition of DOE's mission and existing programs, the unique resources of the laboratories, and the external factors relating to trends in human resource supply, the Panel recommends the following to increase DOE's impact on science and engineering education:

- DOE must continue to emphasize its educational mission primarily through support of graduate students and postdoctoral fellows through university grants and contracts which also serve the research mission of the Department.
- DOE should increase support through expansion of the targeted graduate and postdoctoral research fellowship programs with emphasis given to energy-related areas of greatest projected human resource shortages.
- DOE should increase support for undergraduate research opportunities through the Laboratory Cooperative and Science Engineering Research Semester programs and through DOE-sponsored university-based research programs.
- At the precollege level, DOE should target its efforts where it can realize the greatest impact, namely by providing opportunities for research participation by pre- and in-service teachers to enhance their science background and their instructional capabilities. In this way, DOE can improve the quality of precollege science teachers and thus strengthen the national science and engineering talent pool.
- DOE should emphasize the participation of underrepresented minorities and women in programs at all levels, precollege through post-doctoral.
- DOE should maintain strong continuing education programs at the DOE national laboratories and permit participation by local industries.

CHAPTER I

BACKGROUND

A. Introduction

At the request of the Secretary of Energy (Appendix A), the Energy Research Advisory Board (ERAB) reviewed the Department of Energy's (DOE) activities in education to ensure that DOE is indeed playing its proper role vis-a-vis other federal agencies and the private sector in the support of scientific and technical education and training in the United States. Specifically, the Secretary asked the Board to address the following key questions:

> Do the current education and training programs of DOE address the right needs and are they effectively coordinated?
>
> Is DOE taking full advantage of the resources and capabilities of the national laboratories in the support of education and training?
>
> What responsibilities and mechanisms are appropriate for the Department in the support of elementary and secondary science education, of undergraduate and graduate students, of postdoctoral researchers, and of the general (non-science) public?
>
> Should the Department provide support for undergraduate and graduate research fellowships in energy manpower areas designated in short supply?

In response to the Secretary's request, the Board established a Panel on DOE Science Education Programs. The Panel, composed of Board members and representatives of the education community, conducted a general review of the current education programs of the DOE and of its predecessor agencies.

The Panel further solicited comments on DOE's science education programs from university presidents, deans of education, selected scientists and engineers, heads of major scientific research and professional societies, and from organizations and societies representing precollege science teachers to obtain their perspectives on DOE's education-related programs. Highlights of the responses to the survey are included as Appendix B.

During its several meetings, the Panel heard presentations on science education programs in other federal agencies, including the National Science Foundation (NSF), the Department of Defense, the Department of Education, the National Institutes of Health (NIH), and the National Aeronautics and Space Administration. Presentations were also made on current and proposed science education programs in the DOE national laboratories and on the role of university consortia in these programs. Human resource specialists and representatives of science teaching and research organizations also provided input. Panel meeting agendas, which include a complete list of these presentations, are included as Appendix C. The responses to Panel inquiries and presentations at Panel meetings have been carefully reviewed by the Panel and a synthesis of the information thus obtained has been incorporated in the report as Appendix B.

The Panel's report is structured as follows. The first chapter provides background for this study, including DOE's current role in education and a summary of DOE actions taken as a result of the previous oversight report in 1984.1/ The chapter concludes with an analysis of human resource needs and discusses interventions in the present educational process that could have a significant impact on upgrading the national program of science and engineering education. The second, third, and fourth chapters consider university programs, precollege programs, and public awareness and continuing education programs, respectively, and provide appropriate recommendations.

Throughout the report, the term science education is meant to include mathematics, engineering and technology as well as education in the physical and life sciences, unless otherwise noted. Physical sciences include physics, chemistry, mathematics, computer science, earth and materials sciences, while life sciences include biology, agricultural and medical sciences.

B. Previous Oversight

In 1986, the White House Science Council published a report entitled, A Renewed Partnership.2/ The report emphasized the importance of educational institutions to the national interest because they produce the scientific and technical talent essential for our nation's future. The report further emphasized that the Nation is failing to attract sufficient numbers of talented U.S. citizens, especially women and minorities but also white males, into advanced education in science and engineering. The Council recommended that the federal research agencies substantially increase investments in colleges and universities because ". . . universities today simply cannot respond to society's expectations for them or discharge their national responsibilities in research and education without substantially increased support (p.3)."

In 1983, ERAB assessed the DOE's overall relationships with the university community. The resulting report, An Assessment of the Relationship Between the Department of Energy and Universities and Colleges (DOE/S-0025), analyzed seven major issues and concerns affecting the overall relationships between DOE and the academic community, including education and training. ERAB addressed primarily the Department's responsibilities at the university level and did not make recommendations on precollege level activities and

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1/ An Assessment of the Relationship Between the Department of Energy and Universities and Colleges. (DOE/S-0025).

2/ A Renewed Partnership. Report of the White House Science Council Panel on the Health of U.S. Colleges and Universities, chaired by David Packard and D. Allan Bromley, 1986.

programs. ERAB's principal recommendation for education was that the DOE should "explicitly reaffirm its responsibilities to help ensure that sufficient numbers of highly qualified scientists and engineers are available to meet current and future national energy R&D needs (page 25)." ERAB specifically noted that the primary focus of DOE's support for professional human resource development should be "quality, not quantity." (p. 27)

A more recent DOE report, University Research and Scientific Education Programs of the U.S. Department of Energy (DOE/ER-0296, September 1986) addresses the mutually beneficial partnership between the federal government and the university research community in developing new knowledge and educating the nation's future scientists and engineers for careers in research and development. The report is a valuable summary of DOE's current activities in science and engineering education.

C. DOE's Current Role in Education

1. Missions, Resources, and Legislative Authority

The missions of the U.S. Department of Energy include support of basic research to broaden the nation's scientific knowledge base; development of energy technologies to help provide the nation with a mixed and balanced energy supply system; and national security responsibilities. 3/

Collectively, the Department of Energy represents a significant investment in federal support for scientific research and development -- in FY 88, $13 billion in budget authority including $6 billion in scientific and engineering research. To carry out its missions, DOE is both a user and a patron of a large portion of the nation's scientists and engineers. It comprises a complex of over 50 contractor-operated research laboratories employing in excess of 135,000 people within the complex which has a total replacement cost of well over $50 billion. Within this complex, nine multiprogram national laboratories and thirty specialized laboratories carry out much of the fundamental scientific research and energy technology R&D of the DOE and all of the nuclear weapons-related research and development. These latter facilities account for slightly more than 40 percent of the Department's total field budget and employ over 60,000 people. More than half of these employees are scientists, engineers, and technicians. The DOE, through its national laboratory and university contractors, is responsible for the conduct of research in almost every scientific and technical discipline.

The DOE has vast resources: human resources, research and development laboratories, institutional capabilities, funding, and leadership. Leading research scientists in nuclear physics, high-energy physics, chemistry, biology, and materials science, among others, are employed in the world-class DOE research laboratories. Equally outstanding are the engineers working on the energy technologies as well as the builders of high-energy accelerators,

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3/ DOE's 1986 Annual Report to Congress, p. 2

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fission reactors, fusion reactors, superconducting magnets, synchrotron light sources, particle detectors, and a host of ancillary devices. A steady flow of new, well trained, highly creative scientists and engineers is essential if the Department is to continue to meet its mission responsibilities as successfully as it has in the past.

DOE has specific legislative authority to conduct education-related activities. The Energy Research and Development Administration Act of 1974 requires the agency to sponsor and assist in education and training activities to help assure an adequate supply of human resources for energy R&D programs [Public Law 93-408, Section 101 (11)]. The DOE Organization Act of 1977 specifically directs the Office of Energy Research to be the principal advisor to the Secretary of Energy on education and training activities required to support the short- and long-term basic and applied research activities of the Department [Public Law 95-91, Section 209.b (4)]. The Office of Energy Research has traditionally taken the lead in providing both direct support for science education activities as well as in encouraging other DOE program offices to support education activities related to their own programmatic activities. The Director of the Office of Energy Research periodically reports to the Secretary of Energy on university and other education-related activities carried out by DOE and its laboratories.

Many top-flight scientists and engineers in universities and industries are closely associated with the work in DOE laboratories. Perhaps DOE's greatest contribution to education is in providing this link between universities and the laboratories, enabling many university professors and their graduate and undergraduate students to participate directly in research. This unique opportunity to perform research, when combined with formal classroom instruction, is invaluable to aspiring research scientists. The Panel believes this intertwining of universities with DOE laboratories has greatly advanced both scientific research and education in America.

2. Current Activities

The main focus of DOE's science education programs has been traditionally at the graduate and postdoctoral levels. However, DOE's current science education programs range across all education levels, from precollege to post-graduate. Appendix D summarizes the current range of DOE education activities, while Appendix E provides additional information on the precollege programs.

The principal means by which the Department supports education is through the support of researchers at or associated with universities and colleges. In FY 1987 the Department supported more than 3500 individual university research contracts and grants totaling about $350 million. These awards contribute directly to education by involving graduate, postdoctoral, and undergraduate students in DOE-sponsored research.

DOE has taken several initiatives to strengthen its overall relationships with the university community as a result of ERAB's advice to the Secretary in 1983 on DOE-university relations. Two steps were taken which had immediate relevance for education and support of human resource development. (A summary of the status of recommendations is included as Appendix F.)

First, the Secretary of Energy signed in August, 1984 a policy statement on DOE-university relationships that, among other things, explicitly endorsed DOE's role to encourage and support the involvement of students in each research and technology development program both to meet the DOE's own near- and long-term needs and to invest in the nation's new scientific and technical human resources.

Second, DOE initiated a series of budget increases for the DOE Laboratory Cooperative Program, the principal program activity directed at building research and educational bridges between the Department's national laboratories and the university community (see Chapter II). The budget for this program has grown from $3.5 million in FY 1984 to more than $9 million in FY 1989, with a corresponding increase in the number of students and faculty members involved in laboratory-sponsored research and education programs.

DOE also provides substantial support to education through the programs and resources of its major national laboratories and research facilities. Research laboratories and facilities at the national laboratories are heavily used by university scientists and students, e.g., the Fermi National Accelerator Laboratory, Brookhaven's National Synchrotron Light Source, and Argonne's Intense Pulsed Neutron Source.

In the last two years, DOE has initiated additional science education programs. These include the establishment of the DOE High School Science Student Honors Research Program and of Science Education Centers at five multiprogram energy research laboratories, as well as increased support for high school science teacher research and instructional programs at the DOE laboratories.

Aside from the support provided for graduate and postdoctoral research, direct funding by the DOE for science education activities at all levels was approximately $15 million in FY 1987. Table 1 provides a breakdown of this support at the various levels. In addition to $15 million in direct funding, there is a significant amount of volunteer or "in kind" efforts taking place at the Department's laboratories, often involving individual (or groups of) scientists and engineers working with students and teachers in local or regional schools and universities. It should be noted that the cost of the present precollege program ($1.3M) is a small fraction of the science education program summarized in Table 1 ($15M) and a very small fraction of the total education program ($360M) obtained by summing Table 1 (p. 8) and Table 2 (p. 9). Therefore a substantial funding increase in precollege education would have little impact on the total education budget.

Programs for students and teachers at all levels of the educational system are conducted in laboratories widely dispersed geographically across the nation. A list of DOE's science and engineering education programs, both university-based and those at the DOE laboratories and research facilities may be found in Appendix D. Coordination of these DOE education activities

TABLE I

DEPARTMENT OF ENERGY
CURRENT SCIENCE EDUCATION PROGRAMS:1/
FY 1988

PROGRAM CATEGORIES/DESCRIPTIONS	FUNDING LEVEL ($ IN 000)	NUMBER OF PARTICIPANTS
I. INDIVIDUALS/GROUPS		
A. PRECOLLEGE		
1. Minority Student Research Apprenticeship	$ 120	200
2. DOE High School Student Honors Research	550	260
3. Prefreshmen Engineering Program (PREP)	300	2,000
4. Precollege Science Teacher Research/Training	250	50
5. Laboratory Technical Assistants to Precollege Schools	N/A	N/A
B. UNDERGRADUATE		
1. Research Internships at DOE Laboratories	$1,400	1,000
2. Science & Engineering Research Semester (SERS)	600	120
C. GRADUATE STUDENTS		
1. Graduate Research Appointments at DOE Labs	$2,000	350(EST)
D. UNIVERSITY FACULTY		
1. Minority Institution Faculty Research	$3,000	45(EST)
2. Faculty Research Appointments at DOE Labs	2,500	200-300
3. Short Courses/Institutes for Faculty	500	1,000(EST)
E. POSTDOCTORAL RESEARCHERS		
1. Postdoctoral Research Appointments	N/A	725(EST)
II. INSTITUTIONAL SUPPORT		
A. MINORITY INSTITUTIONS		
1. Minority Institution Research Travel	$ 300	200(EST)
2. Cooperative Research Programs with DOE Labs	2,500	N/A
3. Minority Educational Institutions Assistance Program	1,500	8 projects
III. OTHER		
A. CAREER PLANNING WORKSHOPS	N/A	500(EST)
TOTAL	$15,520	

1/ Does not include DOE on-campus research involving faculty & graduate students ($410M estimated level in FY 1988)

TABLE 2

DOE SUPPORT FOR UNIVERSITY RESEARCH AND DEVELOPMENT AND ASSOCIATED GRADUATE AND POSTDOCTORAL EDUCATION(a)

(1) Office	(2) Research Area	(3) University Support (b) (in M $)	(4) # Graduate Students (c)	(5) # Postdoctoral Fellows (c)	(6) (3)/(4) (in K $)
Energy Research		282.8	3198	635	88
	Basic Energy Sciences	102	1420	300	72
	High Energy Physics	68.5	670	225*	102
	Nuclear Physics	35.8	377		95
	Magnetic Fusion	44.5	331	30	134
	Biological and Environment	32	320-480	80	~80
Fossil Energy		26	325	~60	~80
Conservation & Renewable Energy		24	300	~30	~80
Defense		13	163	N/A	~80
Nuclear Energy		1.5	19	N/A	~80
		347.3	4005	~725	87

*includes both High Energy Physics and Nuclear Physics.

(a) In compiling the data in this table, the panel attempted to separate DOE on-campus direct funding with support provided to the DOE laboratories for faculty and student research and training. Therefore, the number of graduate students and postdoctoral fellows refers to university-based researchers.

(b) FY 1987 operating and capital equipment provided to university-based performers.

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(c) These are the graduate and postdoctoral students supported at universities. In addition, graduate and postdoctoral students are also supported at the DOE laboratory sites by the Office of Energy Research. This includes 700 graduate students at the Lawrence Berkeley Laboratory, 115 at the Ames Laboratory (Iowa State), 111 at the Argonne National Laboratory, 105 at the Brookhaven National Laboratory, 21 at the Stanford Synchrotron Radiation Laboratory, and additional students at other sites. The total number of DOE laboratory-based postdoctoral fellows supported by the Office of Energy Research is 100 at the Argonne National Laboratory, 57 at the Brookhaven National Laboratory, 80 at the Lawrence Berkeley Laboratory, and 45 at the Oak Ridge National Laboratory. The number of graduate students supported in this program is estimated by assuming 12.5 graduate students per million dollars of support.

principally occurs at the staff level through informal working groups and staff level discussions of education programs, opportunities, interests and needs.

D. Developing Human Resources

1. Emerging Problems in the U.S.

The Panel is disturbed by trends in contemporary and future human resource needs in relation to both the quality and quantity of the supply of science and engineering talent. From numerous reports and other source materials examined by the Panel, it is evident that the U.S. is faced with a declining number of individuals prepared to participate in the science and engineering activities of this nation. Also evident is the diminished quality in the performance of those being schooled or trained in science and mathematics, particularly at the precollege level.[4]

Human resource needs are increasing three times faster in science and engineering than in areas such as business and law. The need is greatest in engineering, mathematics, computer sciences, chemistry and physics as compared to the social and life sciences.[5] The following provide indicators of current trends: [6][7][8]

- Data from the National Science Foundation indicate that if present trends continue, by the year 2000 there will be over 100,000 fewer graduates with Bachelors degrees in science and engineering than there were in 1984.
- As a result of low birth rates in the past 10 to 15 years, the number of school-age citizens is declining. At the same time, this group is increasingly non-white. Minority students are now the majority in 25 of the nation's largest school districts. Nationwide, minorities

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[4] "Science Achievement in Seventeen Countries: A Preliminary Report." International Association for the Evaluation of Educational Achievement (IAE), 1988.

[5] Vetter, Betty M., statement before the Joint Economic Committee, U.S. Congress, December 11, 1987.

[6] National Science Foundation, Data Book.

[7] Vetter, Betty M., statement during meeting of Education Panel, Energy Research Advisory Board, Forrestal Building, U.S. Department of Energy, Washington, D.C., October 1987.

[8] Nurturing Science and Engineering Talent: A Discussion Paper. Symposium held at Franklin Institute, Philadelphia. Produced by the Government-University Research Roundtable, July 1987.

will soon make up 30 percent or more of the total school-age population.

- Traditionally, white males have been the primary human resource for meeting national needs in science and engineering. However, the number of white males earning degrees in all science and engineering fields is decreasing. Therefore, as more white males choose not to study science and engineering, we will be looking increasingly to minorities and women to fill the gap.

- While the number of minority graduates with bachelors in science and engineering increased slightly in 1986, the number of doctoral awards to all minorities decreased by 15 percent from a very small base number. In 1986, Ph.D.s in engineering were awarded to six American Indians, 14 Blacks and 25 Hispanics.

- Along with most minorities, women have been virtually unrepresented in certain science and engineering fields and have been underrepresented in nearly all such fields. At all degree levels and in all science and engineering fields, the number of women earning degrees has increased in the past decade while the number of men earning degrees has decreased. However, in many fields the increase in the number of women does not make up for the decrease in the number of men. Since 1984, the number of women obtaining advanced degrees in science and engineering has leveled off as they move increasingly into business, law, and other nontraditional areas.

- Foreign graduate students comprise more than 50 percent of the enrollment of our graduate schools in many technical areas. The number of advanced degrees in science and engineering awarded to foreign students on temporary visas has increased sharply over the last decade and continues to increase. In 1985, foreign students earned four times as many doctorates in science and engineering fields as did all U.S. minorities and U.S. women combined. The U.S. relies increasingly on foreign graduates to fill research and teaching vacancies in some university departments, and, in some technical areas, to fill positions in industry and in government laboratories.

- Although foreign graduate students constitute an important component of our technical human resource pool, they are ineligible to fill certain positions in high technology fields requiring security clearance. The pressure to staff such positions emphasizes the critical need for an adequate supply of graduates who are U.S. citizens.

The Panel concludes that without further attention to their educational needs and choices, U.S. students of both sexes and of most racial and ethnic groups will continue to decrease their participation in science and engineering pursuits. Thus, the flow of new science and engineering talent will diminish. Unless action is taken now to develop human resources among all segments of our society, tapping especially those segments that have been traditionally underrepresented, the DOE and other research-based agencies will not have an adequate pool of scientific and engineering talent available to meet projected needs.

2. Stronger Foreign Competition.

The value of a well educated work force cannot be overestimated. The greater emphasis given by some of our economic competitors to the development of their human resources contributes to higher quality, more reliable, and lower cost foreign products.9/ If the United States is to maintain, let alone improve, its standard of living and quality of life, the U.S. will have to compete with foreign countries, in large part, on the basis of its technological advantage. Tomorrow's desirable jobs will require increased technical knowledge and skills on the part of the work force to operate the sophisticated plants and factories of the future. Tomorrow's workers will need to be able to adapt readily to changes in technologies, and retraining programs will require creative new approaches and considerable investment.

The Panel notes that a report by the International Association for the Evaluation of Educational Achievement10/ indicates that American pupils consistently scored in the bottom half in general science, biology, chemistry, and physics when compared to high school students from 17 other countries. In the U.S., only 57 percent of high school students are enrolled in science courses in any given year and less than 80 percent of American students complete secondary school. The following selected indicators provide a troubling comparison with other countries: 11/

- In the USSR and Eastern Europe, approximately 96 percent of students complete the precollege program and all students study science and mathematics each year (mathematics for ten years, physics for five years, and chemistry and biology for four years.)
- In the United Kingdom, Western Europe and Australia, students study biology, chemistry, physics and mathematics concurrently during the last three years of secondary school.
- In Japan, 92 percent of students complete precollege education. At the upper secondary level, all students take a minimum of 2 years of science and 2 years of mathematics. College bound students take

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9/ Drucker, Peter, "The Changed World Economy," from Foreign Affairs. Published by the Council on Foreign Relations, Inc., Vol 64, No. 4, 1986.

10/ "Science Achievement in Seventeen Countries: A Preliminary Report." International Association for the Evaluation of Educational Achievement (IAEA), 1988.

11/ Gardner, Majorie H., Statement before the Subcommittee on Science, Research and Technology, Committee on Space, Science and Technology, U.S. House of Representatives, March, 1988, p. 5-6.

mathematics every year (through beginning calculus), plus physics, chemistry, biology and earth science, often concurrently.

- In China, the world's largest school system, there is a new national unified science curriculum and new textbooks. All students are required to take physics, chemistry and biology in middle schools.

- In Thailand, a developing country, science and mathematics are taught every year from first through twelfth grade. All high schools -- academic, vocational, commercial and fine arts -- teach science through twelfth grade. All science courses are laboratory-based.

To exacerbate further the problem of precollege science education, a severe shortage of fully qualified, precollege science teachers exists in the nation. The pool of qualified science teachers is far too small to meet current needs. Various studies find that we are failing to attract enough new teachers, and equally important, we are failing to inspire, educate, and keep current those teachers we do have. Selected excerpts from the reports reviewed by the Panel are the following indicators: 12/13/14/

- Preliminary results from a nationwide survey by the Council of State Science Supervisors, currently under way, indicate that science teacher shortages exist in 24 of 25 states reporting so far. Physics teachers are in the shortest supply, followed by chemistry and mathematics.15/

- The average age of high school chemistry and physics teachers in 1986 was near 50 years. This means that many of the current classroom teachers are nearing retirement. At the other end of the pipeline, any teacher training institution that can boast as many as one or two physics or chemistry education majors per year is unusual.

- In 1986, there were 7,100 high schools that did not teach a single physics course because they did not have a qualified teacher. About 4,200 schools did not have a chemistry course; and 1,900 schools did not provide biology for their students. In 1986 also, 66 percent of the

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12/ "Report of the 1985-86 National Survey of Science and Mathematics Education". Research Triangle Institute, November 1987.

13/ "Survey Analysis of U.S. Public and Private High Schools: 1985-86," draft copy. National Science Teachers Association, Washington, D.C., April 1987.

14/ Gardner, Majorie H., Statement before the Sub-Committee on Science, Research and Technology, Committee on Space, Science, and Technology, U.S. House of Representatives, March 1988.

15/ Gerlovich, J., Draft Survey, Iowa Department of Education, DesMoines, May 1988.

primary (K-3) and intermediate (4-6) teachers had never taken a course in chemistry; 80 percent of these teachers had never taken a course in physics; 15 percent had never taken a course in biology.

- Recent research has shown that nearly all 77,000 U.S. public high school science teachers teach out of field, many in three or four subjects for which they fail to meet the minimum requirements recommended by the National Science Teachers Association (NSTA). Sixty-eight percent of high school science teachers have major teaching assignments outside of their major field of study. Increased science requirements for high school graduation in many states have exacerbated the problem to the point where high school principals have great difficulty in filling positions for chemistry and physics teachers with persons who are even minimally qualified.

- As a result of teacher shortages at the secondary levels, more and more teachers are being assigned to cross over from a discipline where they have some confidence into one where they have little preparation. For example, a teacher with a proper teaching credential in biology may well be assigned to teach chemistry and physics also, having taken no more than a single college-level course in these fields. At the elementary school level, teachers rarely have had more than a single science course in college.

- Although the majority of science teachers have earned Master's degrees, these degrees are predominantly in fields of education, not science. This often occurs for reasons other than teacher choice. Science courses are often not available at times when teachers can enroll except through special programs such as institutes funded by the National Science Foundation.

Science teachers in most other countries worldwide complete a 4-year bachelor's degree in a science and mathematics discipline before they enter the professional sequence that prepares them for teaching. In the United States, the large majority of our science teachers do not complete full science majors, but rather meet the lower state certification requirements in science. The teacher education courses in the United States are integrated into a 4-year program. The following are example indicators of science teacher requirements elsewhere:

- In the USSR and Eastern Europe, all teachers complete five years of pre-service college education and return for the equivalent of one year of in-service education every five years.

- In the United Kingdom, Western Europe and Australia, science teachers earn full science baccalaureate degrees; then prepare to teach.

- Japanese science teachers complete undergraduate science degrees and are paid salaries very nearly equivalent to those of college professors.

The Panel feels that the time has come for the U.S. science and engineering community to make a commitment to precollege science and engineering education to ensure a future supply of science and engineering talent. Since teachers are key to upgrading precollege programs, major coordinated efforts must be initiated between the science and engineering community and the education establishment to upgrade both pre-service and in-service programs for science teachers. Concomitant initiatives need to be taken to make precollege science teaching a more attractive and rewarding profession. A unique role that the DOE can play in this important national program is presented in Chapter 3.

3. Effective Use of Limited Resources: Opportunities for Intervention

Studies show that talented students are discouraged or diverted from pursing science and engineering studies not only because of the decline in the quality of math and science education at the precollege level, but also because of cultural changes that have occurred during the past two decades. With the expanded professional opportunities for women, fewer with high scientific talent are going into precollege teaching with a concomitant loss of quality to the teaching profession. Changes in the structure of the typical family unit include a higher incidence of single parent and dual career families and these changes have added pressures to providing adequate supervision for children in the home. Competing with formal classroom instruction are action-packed, highly stimulating television programs and computer games, which often draw students away from pursuits requiring high levels of commitment and concentration, such as science and mathematics.

Therefore, interventions in the educational process are needed to encourage students to seek careers in science and engineering, and to remain committed to study these areas. The Panel concludes that DOE can assist in this process in a unique way, utilizing its singular resources: its talented people and world-class laboratories. To achieve maximum impact, these interventions should be positive, focused, timely, and continuing. The magical inspiration of a young scientific talent by close personal contact with a world-class researcher is one kind of intervention that the DOE laboratories are well positioned to provide.

Current research in education points to optimal targets of focus and provides insight on how to make timely interventions. To achieve maximum effectiveness, the Panel is convinced that actions and programs that encourage students to move into, or remain committed to, science and engineering are most effective when they focus on supporting teachers. When teachers are supported in their efforts to reach all students, a multiplier effect is achieved in reaching many students per teacher. In addition, DOE programs should emphasize participation by all students, including women and underrepresented minorities, intervening at appropriate times when these students are most receptive.

Along the educational time-line from elementary through graduate school, certain points stand out as "nodes," offering high opportunity for effective interventions in the teaching of science and mathematics.16/ Intervention at these times is most likely to strengthen science and mathematics education and commitment and, ultimately, to produce more numerous and more highly motivated scientific and technical personnel.

Nodes occur around the first, seventh, and tenth-grade levels, the sophomore/junior year in college, and again at the postbaccalaureate level. These nodes and common perceptions are discussed in the following.

First Grade. In contrast to parents in Oriental cultures, who view skill in mathematics as a measure of a child's intelligence and school accomplishment, U.S. parents have tended to judge their child's progress in kindergarten and early elementary school years by reading skill. Schools and teachers generally support this view. Common perceptions among Americans are that mathematics is not for everyone, that ability in mathematics is an inborn talent, and that mathematicians are born, not made.17/ Similar perceptions apply to learning science.18/

Seventh Grade. Cultural roles influence students subtly throughout their formative years; however, these role models begin to have concrete impact in adolescence. Mathematics and science are generally considered to be "for boys" and the humanities "for girls." Girls and/or their parents and teachers may perceive mathematics to be "unfeminine."19/ Studies document the common phenomenon of teachers calling on and helping boys in

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16/ Malcom, Shirley M., Equity and Excellence: Compatible Goals, American Association for the Advancement of Science (AAAS Publication 84-14), Washington, D.C., December 1984.

17/ "Mathematics Achievement of Chinese, Japanese, and American Children." H.W. Stevenson, S. Lee, J.W. Stigler. Science, Vol. 231, No. 4739, page 693-699, 1986.

18/ Papert, Seymour, Mindstorms: Children, Computer, and Powerful Ideas, Basic Books, 1980.

19/ Fennema, Elizabeth and Penelope L. Peterson. "Teacher-Student Interactions and Sex-Related Differences in Learning Mathematics", Teaching and Teacher Education, Vol. 2, No. 1, pp. 19-42, 1986.

mathematics classes much more frequently than girls. Examples and language used in science texts and curricula are predominantly those from white, middle-class, Western, male culture.20/21/

At the middle or junior-high school level, students start to be "tracked" into different curricula: those selected for the "academic" track are given more mathematics and science, while those whose environments or cultures may not provide them with the language, analytical, and conceptual skills to perform well on I.Q.-type tests (including PSAT and SAT) are eliminated from the academic mathematics and science courses. These students are often placed in the vocational education or industrial arts track.22/

Tenth Grade. At this node, "low testing" white males, females, and minorities are not encouraged, and are often not prepared, to elect the eleventh and twelfth grade mathematics and science courses that would qualify them to enter colleges or universities where science and engineering study are emphasized. Thus they are not prepared to elect educational programs that lead to careers in science or technical fields and are effectively cut off from future job opportunities in these fields because they fail to compete at this stage.23/

Sophomore/Junior Year in College. At this point, females and minorities are not encouraged to major in science. Discouragement can be related to test scores or to cultural factors. At the same time, there is a frequent and well documented disenchantment of females and minorities who do major in science, and these students have a higher drop-out rate. Around 50 percent of Black and Hispanic youth with SAT scores of 550 and

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20/ Cohen, Rosalie A. "A Match or Not a Match: A Study of Intermediate Science Teaching Materials", Chapter 3 from The Science Curriculum: The Report of the 1986 National Forum for School Science. Edited by A.B. Champagne and L.E. Hornig, American Association for the Advancement of Science, 1987.

21/ Snelling, W.R. and R.F. Boruch. Science in the Liberal Arts Curriculum: A Longitudinal Study of 49 Selective Colleges. Columbia University Press, 1972.

22/ Kay, Nina. W. "A Study to Determine and Test Factors Impacting on the Supply of Minority and Women Scientists, Engineers, and Technologists for Defense Industries and Installations," Center for the Advancement of Science, Engineering, and Technology of Houston-Tillotson College (CASET). NASA, Johnson Space Center, Building 7A, Suite 323, 2101 NASA Road One, Houston.

23/ Ibid.

above, and a declared intention to pursue a science or engineering career, drop out of the pool before their junior year in college.[24]/[25]/[26]/

Postbaccalaureate. At this stage when students are making decisions about career specialization, many encounter feelings of isolation, alienation, disorientation, and low self-image. Cross-cultural communication can be a problem. This is particularly of concern to women when they have classes with foreign national professors who bring to the classroom and research laboratory their attitudes toward women as a subservient group. Even in our own culture, some hold the view that there is "men's work" and "women's work."[27]/[28]/

E. Concluding Remarks

The Panel believes that the DOE must help the country make maximum use of its intellectual resources in order to retain its competitive position in energy research and development and in energy-related industries. The challenges facing educators and employers in the United States are great. As employers, the DOE and other federal agencies have a stake in the success of efforts to ensure that these challenges are met.

To ensure a reliable supply of appropriate human resources, the Panel recommends the development of a five-year plan of coordinated education programs from the precollege to post-doctoral levels, with appropriate evaluation of the effectiveness of the various programs and periodic oversight by appropriate advisory groups. In this context, the key points of the present report are summarized in Appendix G and a full listing of the recommendations is given on page 42.

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[24]/ Ibid.

[25]/ Snelling, Boruch, Rodman.

[26]/ Malcom

[27]/ Kay

[28]/ Cornell University/National Science Foundation. Conference on Women in Science, February 1988.

CHAPTER II

UNIVERSITY PROGRAMS

A. Introduction

The Department of Energy supports graduate and postdoctoral education both through funding for university-based research programs and through funding of selected fellowship programs. These two modes of direct support of advanced students are complementary to each other and are both required to advance DOE's mission. In addition to the above methods of direct funding of university science education, DOE also provides significant support for university faculty and student participation in DOE laboratory research programs.

DOE's principal mode of support to university science education is through support of specific university-based research programs. This funding includes support for a large number of graduate and postdoctoral students. This is a very effective method for ensuring that educational funding is directed to projects that are of specific interest and importance to DOE. This mode of support simultaneously yields research results and educates new scientists and engineers in energy-related fields.

The DOE also has a small program of competitive graduate and postdoctoral fellowships in specialized, energy-related fields of particular relevance to the DOE. This is an important component of DOE's educational program and ensures a supply of high quality scientists in research areas where future manpower shortages are predicted. Presently the approximate percentage of advanced students supported by DOE through fellowships is only 2 percent. The panel concludes that this percentage is too small and recommends that the number of fellowships increase.

To ensure quality and effectiveness, each DOE university education program is specifically evaluated by the hosting institution. In addition, a series of in-depth, longitudinal evaluations are now under way on the effectiveness of the undergraduate semester program and the summer programs for undergraduate, graduate, and faculty members, all of which are described below.

B. Graduate And Postdoctoral Education

The Panel believes that achieving both national and DOE-specific research policy objectives depends heavily on the research universities to educate future scientists, engineers, and science educators and to make advances in scientific and technical knowledge that sustain our economy and ensure our national defense.

Graduate and postdoctoral students are involved in all phases of the DOE's research programs and make a major contribution to the DOE's fundamental science and energy research programs. A number of respondents to the Panel's survey (see Appendix B) confirm the magnitude and importance of the DOE's contribution to the national effort to strengthen the science and technical education system. The Panel believes that the DOE's support of students through university research grants and contracts represents a component of U.S. educational programs of huge proportions and tremendous value. Currently, DOE is providing direct support to many advanced graduate and postdoctoral students through research assistantships and fellowships (see Table 2).

1. Support of Academic Research Programs

The Department of Energy, since its origin as the Atomic Energy Commission, has been both a user and a patron of many of the country's leading scientists and engineers. The importance of the partnership between the Federal Government and the university research community has been emphasized by the Secretary of Energy, John Herrington, and truly remarkable strides have been made in recent years in strengthening DOE-university interactions. The Panel believes that DOE's greatest contribution to education is in their direct support of work in university laboratories where many professors and their graduate students and postdoctoral researchers carry out forefront research which goes hand-in-hand with instruction to produce research scientists.

The Panel is convinced that the DOE's mode of supporting graduate and postdoctoral students through specific academic research programs at universities has been very effective in educating the nation's scientists in energy research. This funding method ensures that student support is directed to projects that are of specific interest to DOE. Furthermore, many of these students and their faculty advisors use major research facilities at DOE laboratories, including, for example, the National Synchrotron Light Source at Brookhaven National Laboratory, the Linear Electron Accelerator at Stanford, and the Tevatron at Fermi National Accelerator Laboratory. Support of university-based research projects involving graduate students is more effective when multi-year commitments are made. Hence, the Panel concurs with DOE's recent change to three-year research grants. In planning and managing an effective university research program, stable long-term funding over a time frame comparable with the completion of doctoral thesis work is essential.

In evaluating the relative merits of supporting fellowships vs. research programs, the Panel concluded that it is important to have a proper balance between the two modes of support. Vigorous programs in energy research on campus are necessary to attract the best students. Such programs can stimulate excitement and interest at the universities in energy research and in the specific R&D programs of the DOE. The Panel believes, however, that fellowship support, because it is more competitive, probably is more effective than research assistant support in attracting the most talented students to energy-related research. Whatever the mode of support, the Panel stresses the importance of the educational content of the graduate research experience. In this context, the significance of the educational contribution provides one measure of the value of university research to the DOE and to the Nation.

The current (FY 1988) level of DOE support for university research and development and the associated graduate and postdoctoral education is summarized in Table 2. Approximately 4000 graduate students and 725 postdoctoral researchers are directly supported on university grants and contracts. In addition to this direct funding, a large amount of indirect support is provided through the facilities usage program of the DOE national laboratories and through the many collaborative research activities between the universities and DOE laboratories that strengthen university research and education.

The Panel believes that, in its direct support of advanced education, the DOE is helping to ensure an adequate supply of highly qualified, well-educated scientific and technical professionals to meet future human resource needs. By using university faculty and students to carry out major parts of its research program, the DOE not only fulfills its research mission but simultaneously invests in the education of our future scientists and engineers. The high quality of these future scientists and engineers is ensured by the highly competitive nature of DOE's current research grants.

2. Graduate Fellowships

The DOE currently supports about 80 graduate fellowships in selected energy-related areas of science and engineering, such as nuclear engineering, health physics, fusion science and technology, and radioactive waste management. The Panel concludes that this fellowship program has several unique merits. Because of the highly competitive aspects of the fellowship program, it ensures that highly talented recipients will do their graduate studies in areas of science and engineering of particular importance and relevance to energy problems, including areas that are relatively underfunded through university grants and contracts. The fellowship program also exposes applicants to energy problems (including how and where they are being attacked) at an early stage of their advanced studies. These features enable a group of particularly talented science and engineering students to become directly familiar with the areas of science and technology in which DOE is most interested. The fellowship program thus provides scientists and engineers with the expertise and encouragement to make contributions in selected energy research areas in their later careers.

On the other hand, students applying for such fellowships are much less mature in terms of research sophistication than those applying for postdoctoral research fellowships. Thus, the applicant's ability to select and/or propose specific research plans may not be very useful as a criterion for fellowship selection, in which case this selected fellowship program in effect is not very different from a "generic fellowship" program. The Panel, however, concludes that these fellowships serve to bring excellent students into areas of energy research and constitute an important component of DOE's educational programs.

Fellowship programs that specifically target underrepresented minorities and women are not widely available at the DOE laboratories. Recently the Lawrence Livermore National Laboratory initiated such a fellowship program, the National Physical Science Consortium. The program is modeled on the Graduate Education for Minorities program which is designed to support graduate engineering students and currently has 200 students in the science and engineering pipeline. The National Physical Science Consortium will offer a unique combination of financial aid, research experience, and monitoring through a joint university-industry program. At LLNL, the first applications for this new program will be accepted from senior undergraduate or graduates during the fall of 1988 with the first fellows starting their programs in the summer of 1989. This program has potential for implementation at all DOE national laboratories.

Follow-up studies show that fellowship programs of the DOE, and its predecessor agencies, have generally been very successful.29/ Information gathered on past fellows by the Oak Ridge Associated Universities indicates that high percentages of all fellowship holders complete graduate degrees and continue to make significant scientific contributions in fields of interest to the DOE. Based on anecdotal responses by former fellowship holders, the Panel concludes that the availability of fellowship support at critical points has strongly influenced the careers of some of today's leading scientists and engineers. The Panel therefore believes that the fellowship program should be expanded beyond the present two percent level to perhaps twice that level, but kept in balance with other aspects of research support.

3. Postdoctoral Appointments

Postdoctoral research experience is an important part of the training in some scientific disciplines. Many young recent PhDs need an extended period of additional research-related experience before they are ready to assume a full research career. This extra time is considered by many academic institutions to be an extension of the graduate education process. Postdoctoral research appointments are also important "entry points" to U.S. science for foreign scientists, many of whom subsequently spend a large part of their careers in the U.S. Approximately 725 postdoctoral researchers are currently supported on DOE university grants and contracts.

The DOE laboratories represent important, in many cases unique, resources for postdoctoral research. The state-of-the-art, often unique facilities and scientific instruments available at the DOE laboratories are particularly well suited to postdoctoral-level research and training. The DOE laboratory system currently supports 350 to 400 on-site postdoctoral researchers each year. These researchers supply a valuable source of new talent for DOE laboratory research and development programs. Laboratory requests for postdoctoral researchers exceed the number of available funded positions by a ratio of two-to-one.

29/ DOE Student Research Participation Program, Profile and Survey of 1979-1982 Participants. U.S. Department of Energy. Frank M. Vivio, Argonne National Laboratory; Wayne Stevenson, Oak Ridge Associated Universities, January 1988.

4. Special Postdoctoral Programs

The DOE supports about 50 special postdoctoral fellowships administered by the Office of Fusion Energy, the Fossil Energy Program, and the Office of Health and Environmental Research. Included in these programs are the Alexander Hollander Distinguished Postdoctoral Fellowships created to be supportive of the mission of the Office of Health and Environmental Research. Distinguished postdoctoral fellowships are also offered by a number of the DOE laboratories. The Panel believes that the distinguished postdoctoral fellowship programs are effective in attracting top level talent to the laboratories, thereby contributing significantly to upgrading the quality of research at the laboratories and to elevating the perception of the laboratories by the research community.

The Panel concludes that the research mission of the DOE will be severely curtailed if additional numbers of bright and talented young people are not encouraged to enter scientific and technical fields of particular relevance to fundamental science and to energy research.

Recommendations

1. The Panel recommends that the DOE continue to emphasize its educational mission primarily in support of graduate students and postdoctoral fellows through university grants and contracts which also serve the research mission of the Department. The recommended level of support should be increased in those disciplines of special importance to the DOE's fundamental science and energy mission.

2. The Panel recommends that stable and predictable funding levels be provided for university-based research projects involving students by making multi-year commitments.

3. The Panel recommends that targeted graduate and postdoctoral research fellowship programs be increased by the DOE in areas of science and engineering of particular importance to energy programs, with particular emphasis given to areas that have limited university research funding. Special targeted fellowship for underrepresented minorities and women should be established.

4. In the fulfillment of its mission to support advanced education and research, the Panel recommends that the Department continue to focus on quality in its efforts to develop human resources.

C. Undergraduate Education

Undergraduate students represent a real opportunity for the Department to directly influence specific career choices in scientific and technical fields. Traditionally, the DOE has accomplished this by providing opportunities for hands-on research experience. These programs have proven to be excellent vehicles to stimulate and encourage young college students to pursue graduate-level degrees in scientific or technical fields of direct interest and relevance to DOE.

DOE provides support for undergraduate students and undergraduate teaching faculty principally through the University-DOE Laboratory Cooperative Program (Lab-Coop Program) and the new DOE initiative, the Science and Engineering Research Semester (SERS).

1. DOE's Laboratory Cooperative Program

The objective of the Lab-Coop Program, initiated in the mid-1950s by the Atomic Energy Commission and administrated through the Office of Energy Research, is to attract younger scientists and engineers into energy-related careers by providing "hands-on" research experience at the national laboratories for students and faculty. Up to 1200 undergraduates and 250 faculty members per year participate in summer research and instructional programs conducted at over 30 DOE laboratories and contractor facilities. About half of these participants are from small, predominately undergraduate institutions. (Traditionally, about half of the nation's science graduate student population also come from such institutions.) The students work as members of laboratory research teams, sometimes in conjunction with faculty members from their home institutions. The number of participants is expanded somewhat (estimated at about 20 percent) by supplemental support from the research budgets of the national laboratories in recognition of the mutual benefits to the laboratories and the visitors.

The program is particularly attractive to students and faculty coming from small, non-research colleges and universities, especially those located near the national laboratories. In recent years, the program has encouraged and emphasized more participation by women and minorities. More than one-third of all the undergraduate student participants in the Lab-Coop Program from 1979 to 1982 were women (for comparison, 11 percent of all scientists and engineers are women while 16-17 percent of all science and engineering students are women.); eight percent of the participants were Black and three percent were Hispanic (for comparison 2.5 and 2 percent of scientists and engineers are Black and Hispanic, respectively.)

The Panel believes that this program has proved to be an excellent vehicle for exposure of undergraduates and faculty to the research and development activities of the DOE national laboratories. Its record of success is impressive: more than two-thirds of the undergraduate participants pursue graduate study in science, engineering and related disciplines; approximately 60 percent of the students report that this is a direct result of their Lab-Coop experience.30/ The program has been especially effective in encouraging women and minorities to go on to graduate study and careers in science and engineering. In a survey conducted by the Department and published in 1988, "The U.S. Department of Energy Student Research Participation Program," 40 percent of the female participants indicated that participation in the program had influenced to a large degree their decision to attend graduate school, whereas only 23 percent of the males made a similar indication.

The program received a large funding increase in FY 1984 and has continued to increase each year since. The Panel believes the Lab-Coop Program to be especially worthy of increased funding. Student interest is high: for each position offered, five applications are received.

Without exception, the national laboratories have contributed internal funds to support their undergraduate education programs in recognition of their unique mission and, in some cases, specific geography. To the extent possible, this supplemental support comes directly from the budgets of the laboratories and depends significantly on the commitment and interest of the laboratory staffs. Through their annual institutional plans, the national laboratories report strong interest in this program as a source of talent and vitality, and for maintaining the life blood of many fields important to national energy security. The Panel believes that several laboratories have made an excellent effort and should be commended for developing programs that are innovative and stimulating; the laboratories should also be commended for developing programs that are designed to recruit women and underrepresented minorities into science and engineering. These programs, which emphasize intensive "hands-on" undergraduate research experiences, can serve as models for other Federal and industrial laboratories.

2. Science and Engineering Research Semester (SERS)

The Science and Engineering Research Semester is a new program initiated in FY 1987 as an integral part of the Lab-Coop program. This program was initiated as one response to the Secretary's interest in significantly expanding the opportunities available to students at the DOE laboratories. Undergraduates participating in this program are selected from applications solicited nationwide and receive a 16-week semester research/instructional appointment at one of five participating national laboratories: Argonne National Laboratory; Lawrence Berkeley Laboratory; Pacific Northwest Laboratory; Oak Ridge National Laboratory; and, Brookhaven National Laboratory. In contrast to the Lab-Coop Program, students may receive academic credit for their participation in the SERS program by taking courses sponsored by nearby universities and some students receive academic credit for the research experience as well. Some laboratories have large numbers of resident university-accredited staff members able to oversee students who receive academic credit for their laboratory experience.

30/ Ibid.

The SERS program began in the Fall and Spring semesters of 1987-1988 with approximately 120 students. Plans are to expand gradually the program to 400 to 600 participants. One attraction of this program is that students are exposed to DOE laboratory research and specialized instrumentation as part of their academic training.

3. Faculty Research Participation

The undergraduate faculty research participation program provides the opportunity for faculty from predominantly undergraduate institutions to participate in state-of-the-art research projects during the summer and academic year. The Panel believes that these programs provide a valuable opportunity for those faculty who are interested in research but have limited opportunities to participate in advanced research because of institutional limitations (small liberal arts colleges, undergraduate engineering colleges, etc). This program allows these faculty members to participate in new developments in their research fields, enabling them to continue to transmit the latest knowledge in their fields and to share with their students the excitement of discovery. The DOE laboratories which sponsor this program generally receive two to three times as many qualified faculty applicants as there are funds available to support them. The Panel notes that because the faculty participate more actively in the research and because the costs of faculty stipends considerably exceed those for students, faculty appointments are funded primarily from laboratory research funds, which leaves the Lab-Coop funds primarily for undergraduate student appointments. The Panel recommends that the DOE continue support of the Faculty Research Participation program, at least at its present support level.

4. Discussion

The Panel believes that the Department should continue to emphasize its research programs for undergraduate students and their associated faculty. Undergraduate contact with faculty most active in research and consulting is regarded as a major factor in encouraging students to pursue careers in science and engineering. The Panel, therefore, believes that the DOE should significantly enhance its support of undergraduate research by encouraging principal investigators supported by DOE grants at universities to actively recruit undergraduates to participate in university-based research programs. Such encouragement could be provided in the DOE program announcements describing university funding opportunities.

The Panel considered the issue of undergraduate fellowships in energy manpower areas designated to be in short supply and concluded that such targeted fellowship programs are more effective at the graduate and postdoctoral levels.

The effectiveness of all the undergraduate programs supported by DOE should continue to be closely monitored and evaluated. Programs should be expanded based on comparison of the results of these evaluations. Particular attention should be paid to encouraging women and minority students to pursue their interests in science and engineering studies at the undergraduate level. As noted on page 14, women and minority students experience a higher drop-out rate before their junior year in college than their white male counterparts. For such former students, re-entry programs in technical areas of greatest need to the DOE could be mutually beneficial.

Recommendations

1. The Panel recommends that the DOE increase support of undergraduate students in the Lab-Coop and SERS Programs. Priority should be given to women and underrepresented minority students and to students from institutions having little or no in-house research activities.

2. The Panel recommends that the DOE encourage principal investigators to actively recruit undergraduates as participants in ongoing, DOE-sponsored university-based research programs.

3. The Panel recommends that the DOE support the development of vigorous programs explicitly to attract and retain a larger fraction of underrepresented minorities and women (including those re-entering the field) undergraduates in science and engineering, particularly in areas of greatest need to the DOE.

4. The DOE should maintain at least the current level of support in the Faculty Research Participation Program for faculty from undergraduate institutions, particularly faculty from small, non-research institutions who might not otherwise have an opportunity to participate in advanced research.

Chapter III

PRECOLLEGE EDUCATION PROGRAMS

A. Introduction

The DOE cannot afford to ignore the precollege education system in the U.S. It includes 45 million students, 2.5 million classroom teachers, and an annual budget of nearly $200 billion. Many recent reports have highlighted the decline of the academic achievement of U.S. precollege education. While this decline adversely affects the potential talent pool for DOE research and development activities, it is not feasible for the DOE to tackle these problems alone. To achieve any headway with improving the quality of precollege science education and achievement, concerted efforts by the DOE together with the National Science Foundation and the Department of Education will be needed. In this chapter we present some initiatives which take advantage of the unique resources that the DOE can offer to address these problems.

DOE's interest in precollege education results from its need for a continually replenished supply of qualified scientists, engineers and technicians. In this context, DOE has a responsibility to join the national effort to assist and support educators in providing quality science and mathematics instruction at the precollege level. Precollege education programs include those programs directed at students and faculty in elementary and secondary schools and in community colleges (see Appendix D and E.)

The strength of the Department's precollege education programs lies in the DOE laboratories, their staffs, and their facilities. Exposing students and teachers to "live science" in a DOE laboratory can ignite the interest and intellectual curiosity of students and can vitalize and revitalize teachers and the members of the teaching profession. Even informal encounters with scientists can be pivotal in stimulating young people to pursue careers in science and engineering.

Toward that end, the Department supports precollege education programs that encourage young people to pursue careers in energy-related scientific and technical fields. As pointed out in Chapter I, the first, seventh and tenth grades are particularly important intervention points when encouragement of science and mathematics studies can be particularly effective. Some DOE programs are aimed at enhancing the knowledge base and general scientific literacy of all students in order to enhance the overall capabilities of the U.S. work force, while other programs provide access to state-of-the-art research facilities for education and research activities for committed students and teachers.

In reviewing DOE's current precollege programs, the Panel believes that the Department and its laboratories have done a remarkable job in providing opportunities for the best and brightest students to work directly with leading research scientists. These early contacts with the exciting world of advanced science serve to encourage these young people to pursue their interests in science to the limits of their capabilities. The Panel believes this to be an appropriate and unique role for the DOE and encourages the strengthening of these programs.

The discussion of the precollege education programs starts with a summary of the present precollege program (both in the text and in Appendix D and E). In assessing these programs, the Panel identified areas where improvements were needed, both from a programmatic and management standpoint. These findings are then presented, followed by further discussion of the role of the DOE in precollege education and a brief summary of the overall findings.

B. DOE's Precollege Programs

Most of DOE's precollege effort is focused at the high school level. Several DOE laboratories, however, have also conducted programs at elementary-school and community-college levels. Most of DOE's current support for precollege programs goes to programs conducted at the DOE laboratories. These laboratory efforts include both formal and informal activities that are funded with direct support from DOE or are carried out through a combination of resources including research program funding, grants, and volunteer efforts.

1. DOE National Programs

At the high-school level, most of the DOE laboratories provide opportunities for high-school science teachers and their high-achieving students to become involved in laboratory research and/or to take advantage of laboratory resources to develop materials for use in high-school science classes. Opportunities are also available at many of the DOE laboratories for students, principally minority students, to learn about future careers in science and engineering while participating in apprentice learning programs. Programs for teachers include training institutes and opportunities to develop instructional materials.

The principal emphasis of DOE's current precollege programs, however, is on providing opportunities for the most competent and confident high-school science students and teachers to interact with scientists and engineers at the DOE laboratories. The most nationally visible effort of this type is the DOE High-School Science Student Honors Research Program. Initiated in 1985, the Program involves students from each state, including Puerto Rico and the District of Columbia. Students participate in a two-week summer research and instructional program at participating DOE laboratories in such research areas as computer science, environmental research, life sciences, elementary particle physics, and superconductivity. A similar program, planned for FY 1989, will target high-school science teachers.

The principal DOE precollege program not conducted at or with the national laboratories is the Prefreshman Engineering Program (PREP). Engineering (or engineering-affiliated) schools at universities compete for funds to conduct summer institutes for its target audience. This Program encourages women and minority students at the junior and senior high school level to consider careers in engineering or related fields. The PREP program supports approximately 2500 students each year. Statistics indicate that over 60 percent of the women or minority students who have participated go on to enroll in college-level engineering or science programs. Some individual PREP projects report that over 80 percent of their participants go on to major in college engineering/science programs.

The Department also supports summer research institutes for precollege students and teachers. During FY 1987, over 300 high-school science teachers and 460 science students from junior, middle and senior high schools participated in summer research and instructional programs at DOE facilities. This total includes programs that each year target more than 200 minority students who work as laboratory research apprentices.

2. Laboratory Initiatives

The Panel finds that the degree of success of the DOE precollege programs is evident in the willingness and interest of staff at individual DOE laboratories not only to carry out DOE-supported national programs but also to initiate complementary programs with local schools.

Significant among the model programs initiated by the individual DOE laboratories are those that respond more specifically to educational needs of teachers to remain current in their fields and to gain motivation and inspiration for renewing their professional commitment. Leading among these teacher programs are institutes and jobs programs designed to enhance the preparation of science and mathematics teachers and to provide summer employment. Similar programs are also conducted for high school students, particularly for women and minority students.

Introduced in 1984 at several DOE laboratories is a national teacher program, Residence in Science and Technology (REST), which has the potential to become a program that all DOE laboratories may conduct in common. Current participating laboratories are Argonne, Brookhaven, Lawrence Berkeley, Lawrence Livermore, Los Alamos, Oak Ridge, and Pacific Northwest Laboratory. This program targets outstanding teachers, selected nationally, and allows them to participate in laboratory research and to develop instructional strategies and materials based on this experience. A significant component of a number of the teacher programs is the instructional materials the teachers develop from their laboratory research experience. For their work, some of these teachers are awarded graduate-level education credits by agreement with regional universities.

Programs at the DOE national laboratories also target a local audience of high-school and/or junior-high or middle-school teachers and students throughout the year. Programs that are primarily conducted for outstanding students (and their teachers) include research participation, special events, and workshops. Programs directed at minority and female students include curriculum projects, in-house tours, lectures, and workshops.

A variety of special events conducted at the DOE laboratories recognize achievement in science education and provide encouragement to science and mathematics students and teachers. Sponsorship of science fairs, presentations at meetings of school administrators and school board members, publication of student project books based on current research at the laboratories, presentation of science awards in awards ceremonies at the schools, scholarships and awards for excellent teachers and students are examples of special events.

The Panel notes that very few of the current precollege programs at the laboratories are designed for teachers who are teaching outside their curriculum areas, for remedial students, or for the disabled. What programs there are to increase general scientific literacy include direct classroom instruction, outreach through professional organizations or partnerships with school districts or industries, and ad hoc support activities such as loaning equipment to schools or providing personnel to judge science fairs or to tutor students.

The Panel commends the Department for the number, variety, and quality of existing precollege initiatives, a number of which began during the last three years. The DOE laboratories have clearly responded to local and regional interests by developing excellent programs that meet educational needs in local and regional communities.

The Panel believes that a healthy precollege science and mathematics education system is essential to carry out the Department of Energy's mission. From available indicators,31/ the Panel finds that the U.S. precollege education system needs strengthening. Because the precollege education system is huge, the DOE cannot expect and should not alone try to influence the entire system. DOE can help by closely working with other Federal agencies, business and state and local governments to improve the system with steady, reliable and encouraging support. The Department can be particularly effective with carefully selected education programs, as discussed in the next section.

C. Areas for Improvement

1. Targets for DOE Programs

The Panel concludes that a stable, more targeted effort by DOE in precollege education is needed. The Panel finds that the DOE has not yet concentrated its efforts where the most good can be done, particularly at the key intervention points, or nodes. In maximizing the effectiveness of precollege programs, teachers are key. Through the multiplier effect, teachers can reach the largest number of students and attract and retain them in science and mathematics studies.

31/ The Science Curriculum: The Report of the 1986 National Forum for School Science. Edited by A.B. Champagne and L.E. Hornig, American Association for the Advancement of Science, 1987.

Precollege science teachers tend to be isolated from new developments in their disciplines within a few years after they leave college and enter the classroom. They have few opportunities for keeping current in their fields or for developing the kind of collegial relationships with research scientists that could help to enhance the status of the teaching profession. The context in which teachers work often mitigates against quality instruction. A myriad of non-instructional duties such as hall monitoring, lunch duty, and discipline problems both divert teacher attention from their central instructional roles and inhibit their participation in DOE-sponsored educational opportunities. To provide a more favorable environment for teacher participation in in-service programs, the DOE laboratories should establish partnerships with the schools, and create bonds with the state and local school authorities, the unions and the teacher's professional associations. Several programs that allow teachers to practice "hands-on science" are currently in place at the DOE laboratories (See Appendix D and E). The Panel finds that insufficient attention has been given to how these teachers could influence their own institutions once they return. The DOE laboratories have not taken full advantage of the extensive evaluations made by NSF and other agencies that offer guidance for designing experiences for teachers that are likely to result in substantive long-term change.32/

The Department also has few programs to update the average teacher, retrain the crossover teacher, and excite the capable non-science oriented student. Current DOE programs tend to aim at those teachers and students who are already committed to and qualified in science. While some DOE programs exist specifically to draw traditionally underrepresented minorities and women into the pool of science and mathematics students, the effort in this area is not strong and does not effectively use the extraordinary potential of the DOE laboratories to enhance science education in the United States.

Further, most DOE precollege programs for students concentrate on stimulating the interest of high-school students. Few programs are focussed on students in the pre-high-school years, and few programs have been developed that address effectively the issue of improving science and mathematics education as early as possible in the school experience. As discussed in Chapter I, early intervention can have a great impact on the science education of young students, especially on minorities and females and especially when the intervention targets the teachers -- not necessarily science specialists -- who work with these underrepresented students.

The Panel further finds too low a number of highly talented young people electing careers in science teaching. The Panel discussed several mechanisms to increase the number of talented young people entering science teaching careers. Particularly promising is a teacher training fellowship program for support to students, with an undergraduate degree in science, mathematics, or

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32/ Opportunities for Strategic Investment in K-2 Science Education: Options for the National Science Foundation, Volume 1, 1987, pp. 94, 95.

engineering, to complete a Master's degree in Education. Such a program would offer strong incentives to highly talented people to enter science teaching careers at the precollege level. The Panel recommends that the DOE strongly endorse and participate in efforts by the National Science Foundation and the Department of Education to establish such a graduate fellowship program. Opportunities for summer research assignments to science education students could also have a significant impact on enhancing the attractiveness and effectiveness of this science teacher education program.

Another promising program for enhancing the quality of precollege science education would allow professional scientists and engineers to divide their time between precollege science teaching and DOE laboratory research. Specific advantages of this approach include continual professional vitalization for in-service science teachers through hands-on research experience, association with active and productive scientists, enhanced professional recognition, and increased financial rewards. One implementation of this concept could be through alternating teaching activities during the academic year with full-time research participation at a DOE (or industrial) laboratory during the summer months. Another possible implementation could combine precollege teaching with research work at a DOE or industrial laboratory during the work week, with full time research participation during the summer. The Panel feels that this approach has inherent flexibility with regard to the fraction of time allocated to teaching vs. research, how the time allocations are distributed during the school or calendar year, and where the research is carried out (DOE laboratory or industry). The Panel believes that the DOE could play an important role in catalyzing such a program which could then be extended to other settings and formats. It is felt that this program has the potential for meeting the needs of a large number of in-service teachers and school districts in a modality that would be acceptable to the present education infrastructure.

2. Management

With several exceptions, the precollege activities initiated at the laboratory level have been "bootlegged" from support for university-level programs or supported by volunteer efforts. The Panel believes that volunteerism is fine, but it thrives if adequately funded so that a stable, ongoing commitment is achieved. The Panel thus concludes that stability of commitment and funding is needed to sustain the infrastructure of precollege education programs.

The Panel finds that the Department's limited education resources are not used as effectively as they might be at the precollege level. An improved infrastructure is needed to support the DOE precollege education programs. Because no formal network now exists, effective strategies developed at one of the DOE laboratories are rarely disseminated among other DOE facilities, nor to those in the educational community who could use them. No long-range planning has taken place that would include a mechanism for reaching consensus among the DOE laboratories on program priorities, objectives, evaluation, and dissemination of programs and materials.

Currently, few mechanisms are in place to track program participants or to monitor the fraction of the students going into graduate level work and in particular into specialized energy areas. By virtue of the size and centralized control, the Department could, presumably, coordinate activities and disseminate results of program evaluations to an extent currently not possible or probable elsewhere.

The DOE has also not taken full advantage of the strength to be gained by establishing communication networks to facilitate cooperative efforts with private industries and other federal agencies, such as the National Science Foundation, the Department of Defense, the Department of Education; professional organizations such as the National Science Teachers Association, the American Association for the Advancement of Science, the Association of Science Technology Centers, the Council of State Science Supervisors; colleges and universities; state agencies; etc. Interagency collaboration is difficult, but it must be done to enhance the effectiveness of the education programs undertaken by DOE. Useful partnerships with other entities could and should be fostered using the unique resources and strengths of each.

D. DOE's Role

In general, the Panel recognizes that the DOE can play a leadership role by developing sustained partnerships between the DOE laboratories and the schools to promote the development of a broad pool of competent and interested science learners. Through such partnerships, the Department is in a position to promote wide interest and understanding of science and of the need for quality science and mathematics education.

In collaboration with the National Science Foundation (NSF) or other agencies, the DOE could develop a comprehensive teacher-enhancement project which would involve similar programs conducted across the country. With science educators involved in planning and implementing programs, and with the support of local school administrations, these programs could go a long way toward invigorating science and mathematics in-service programs. Science and mathematics teachers generally regard the NSF's Science Teacher Institutes as the most successful of the 1960s programs to develop science educators. Many teachers deplore their demise. Extensive NSF evaluations of that program give guidance for future planning, e.g., how to design experiences so that they are likely to result in substantive long-term change.33/

To develop programs that reach a broader group of teachers and students, the DOE will need approaches and strategies different from those used to reach confident and competent teachers and students. Special efforts are needed to enlarge the pool of talent by clearly showing the general student the excitement, methods, tools, processes, and implications of scientific inquiry. In particular, more opportunities in non-traditional settings could be offered to those teachers who most need help but are least likely to seek it.

33/ Ibid.

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Establishing a communication network among the DOE laboratories would allow the effective DOE precollege programs to be better exploited; ideas could be shared; and the various program models can be monitored and evaluated. In addition, there should be a coordinated effort to develop new programs based on formal needs assessments and program evaluations. A part of this new infrastructure could be a five-year education program plan which would include a mechanism for reaching consensus among the DOE laboratories on program priorities, objectives, evaluation, and dissemination of programs and materials. But unless the Department is willing to provide appropriate resources to sustain its effort for five years or more, the effort will not be worthwhile.

E. Findings

The Panel finds that the U.S. precollege education system needs strengthening, that DOE has an important role to play in strengthening precollege education, and that the DOE should do more in precollege education than it has in the past.

The Panel finds that the strength of the Department's precollege science education programs lies in the DOE laboratories, their staffs and their facilities. The Department and its laboratories have done a remarkable job in providing opportunities for the best and brightest young students to work directly with leading research scientists. The Panel finds that the degree of success of the DOE precollege programs is due to the willingness and interest of scientists and staff at DOE laboratories not only to carry out DOE-supported national programs but also to initiate complementary programs with local schools.

The Panel concludes that the DOE needs to concentrate more of its efforts in the precollege area where it can do the most overall good: namely at teachers. Through the multiplier effect, teachers can reach the largest number of students at key intervention points and attract and retain them in science and mathematics studies. The Panel finds that an improved infrastructure is needed to support the DOE's precollege education programs. The DOE needs to take advantage of the strength to be gained by establishing communication networks to facilitate cooperative efforts with other federal agencies and private industries. The Panel further finds too low a number of highly talented young people electing careers in science teaching.

Recommendations

1. The Panel recommends that the Department establish an infrastructure, a communication network, and a five-year plan to provide stable support for precollege education programs.

2. The Panel recommends that the Department strongly endorse and participate in the efforts by the National Science Foundation and the Department of Education to establish graduate fellowship programs for a Masters degree in science education for science/engineering/technology baccalaureate graduates.

The Panel further recommends that DOE provide opportunities for future science teachers to participate in laboratory research programs.

3. The Panel recommends that DOE initiate a program for allowing in-service science teachers to divide their time between classroom teaching and participation in DOE (or industrial) research during the calendar year.

4. The Panel recommends that the Department develop formal partnerships, and strengthen existing partnerships, between DOE laboratories, teachers, and state and community organizations dedicated to enhancing student involvement in science, mathematics, and engineering.

5. The Panel recommends that DOE target students who demonstrate high achievement, commitment, or potential in science, and involve these students in formal and informal programs that allow personal encounters between them and working scientists.

6. The Panel recommends that DOE base its precollege programs on the following guidelines which ensure that programs reach the largest number of students and are most effective in retaining them in science and mathematics education. These guidelines should be either on the followed or modified, depending on each DOE laboratory's unique strengths and on the successful education programs that are currently in place.

- Concentrate on developing programs for teachers. Emphasize programs that 1) help teachers enhance their science skills and understanding; 2) provide teachers (and students) with hands-on science activities; and 3) encourage understanding of the relationships between science, technology and society.
- Assess needs involving both educators and scientists in the process.
- Evaluate the effectiveness of ongoing programs.
- Target the grade levels that individual laboratories can reach effectively. Some programs should give special consideration to youn students and their teachers at the elementary and middle school level
- Develop and support vigorous programs to stimulate and nurture the interest of young women and underrepresented minorities to participate more fully in the DOE education programs in science and engineering.
- Collaborate with educators and researchers to develop instructional materials for taking advantage of state-of-the-art audio-visual aids, computer technologies and other electronic delivery systems, and strategies for exploring relationships between science, technology and society. Efforts in this area should focus on developing materials that can be integrated into or used as a supplement to existing science curricula.

CHAPTER IV

PUBLIC AWARENESS AND CONTINUING EDUCATION

A. Public Education And Awareness

The Panel believes that a well educated and informed citizenry is extremely important to the success of the Department's mission. The best efforts of capable scientists and engineers to develop and transfer new, energy-related technologies may be in vain if the general public does not understand and, thus, may be unwilling to support technologically based advantageous policies and energy options. As energy policy evolves, public acceptance is necessary for its implementation. Public acceptance may range from conserving energy to making choices on various energy options and environmental issues. To make wise choices, the public needs a basic understanding of scientific and technical issues in order to distinguish between reasonable and unreasonable policies.

The importance of education to the DOE mission should be emphasized in official DOE statements to the public. Key ideas that could be presented are given in Appendix G.

Educating the public is a multifaceted task, requiring cooperation with schools, state and local agencies, industry and the media. The Department can make some inroads into public energy education by sponsoring library and museum exhibits, energy fairs, TV science spots, and other energy awareness programs. Direct consumer mailings and speakers bureaus coordinated through local agencies or utilities are other possible avenues of contact with the general public.

The long-term results, though, will come from efforts that go beyond consumer or citizen education and address the root causes of the barrier between technology and society; namely, the perception by many adults that average people cannot understand science and mathematics. Many Americans are fearful of studying mathematics and science, and distrust technology. Parents and even teachers may convey this perception to their children at a very early age. Experiences in Pacific Rim countries demonstrate that mathematics and science can be successfully taught to most precollege students.34/

The Panel believes that children may provide the ultimate channel through which science education materials reach parents, since the "class" in adult education efforts is dispersed. Fact sheets, science and math homework involving parent participation, even a series of educational video cassettes that children can check out from their school libraries and take home to share

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34/ "Mathematics Achievement of Chinese, Japanese and American Children." H. W. Stevenson's and J. W. Stigler, Science Vol. 231, No. 4739, 1986.

with their families, should be investigated as potential methods for educating adults, to the mutual benefit of children, parents and teachers.

The Panel believes that the best contribution the Department can make to public science education is to encourage DOE laboratory scientists and engineers to reach out to the parents of young children through the schools and through such school-based groups as the Parent Teacher Associations and science museums. One innovative program of this kind is the "Family Math Series"35/ developed by staff at the Lawrence Hall of Science at the University of California at Berkeley. Through the parents work with their school-age children on math problems keyed to what the child is learning in school. The program is positive, nonthreatening and fun, and starts with activities for very young children.

B. Continuing Education

The Panel recognizes that, because of the increasing rapidity of advances in science and technology, the need for continuing (or lifelong) education has assumed increasing importance in upgrading both the knowledge base and the specific skills of employees. For example, in today's technological work force, the use of computers is all-pervasive, yet many mature practicing scientists and engineers have no formal training in computer science. Universities, professional societies, and industrial companies have established a large number of intensive summer minicourses, focused evening courses, and video courses (sometimes with tutors) at the workplace and other modalities to meet the needs for continuing education of today's technical workforce.

In these endeavors, the DOE laboratories could play a leadership role in upgrading the skills and knowledge base of the American workforce. The DOE laboratories are in an excellent position to provide continuing education for their own personnel, at both the professional and technician level. Once in place, continuing education programs at the DOE laboratories could then become available (on a full cost recovery basis) to meet the continuing education needs of local industry, particularly DOE contractors or industrial personnel requiring specialized training in energy-related science and technologies.

Continuing education and intern programs at the DOE laboratories could have a significant impact on upgrading the skills of technicians. Since World War II, the armed services have played an important role in the training of technicians to meet the nation's defense needs. The DOE labs could play a similar role in the training of technicians to meet the nation's energy needs. Such a program could be attractive to women contemplating reentry into the work force and to minority workers desiring upward mobility.

35/ Jean Stenmark et al., Family Math, copyright 1986 by the Regents of the University of California, Berkeley, California.

C. Industrial Support Of Energy Education

The Panel believes that the DOE should encourage the energy industries to strengthen their support of science education at all levels. Private-sector support of precollege and higher education and continuing education takes many forms in the technical and scientific areas related to energy production, distribution and use. A few of the more prevalent support activities are discussed here.

The energy industry, both collectively and as individual companies, is involved in and concerned about scientific and technical education. Most major companies provide some form of financial aid directly to teachers and students who are studying or participating in research programs that are energy-related. Often companies establish endowed chairs or professorships, graduate fellowships and undergraduate scholarships at universities and colleges. Perhaps even more frequently, teachers in nearby educational institutions are employed by industries as part-time consultants or to instruct company personnel, students are given on-the-job training, and cooperative work programs are undertaken. This type of support is estimated to amount to more than $1 billion annually. The Panel believes that the energy-related industries have further potential for the support of educational programs and that the DOE could effectively encourage and coordinate additional contributions.

In recent years, equipment manufacturers have been particularly generous (partially as a result of enlightened tax policy) in donating used equipment or in offering large discounts on new equipment to educational institutions. This equipment ranges from computers to test apparatus and instrumentation to operational models.

Many energy-oriented companies also offer "continuing education" courses to their employees, often partially on company time. These courses run the gamut from project management to advanced technology and are generally focused on improving the professional skills and knowledge of key employees. In some companies, such as engineering-construction firms, these courses provide the best means for upgrading and/or retraining personnel.

Two industrial activities that relate directly to the Panel's concerns are summer employment of teachers and students, and sponsorship of teacher workshops. All companies contacted by this Panel indicated that they have consistently employed promising students and deserving teachers during the summer. The Panel feels that the potential for industrial participation in programs involving part-time precollege teaching coupled with part-time industrial research and development should be explored.

Several recent reports by professional societies have emphasized the vital importance of industrial employment for students and teachers. Not only does such experience help the chosen teachers and students meet their financial obligations while contributing to energy-related work, these experiences also broaden their horizons and focus their talents on the challenges of the real world. At the same time, college and university -- and even high-school -- officials have been emphatic that, without this help from industry, they would not be able to keep many of their best faculty members and superior students.

The energy industry sponsors teacher workshops throughout the nation. Often this is done through technical societies such as the American Society for Mechanical Engineers and the American Nuclear Society, or through trade organizations such as the United States Council for Energy Awareness. Such workshops often contribute to the development of energy-related courses and curricula. The potential for such workshops to have an even greater impact should be explored.

Recommendations

1. The Department should provide incentives to its own scientific and technical personnel, as well as those at the national laboratories and universities, to take the initiative in developing energy-relevant adult education programs and working with local school groups to develop parent outreach programs in science education.

2. The Panel recommends that the DOE strengthen continuing education programs for both professionals and technicians at DOE national laboratories and enlarge those programs to permit participation by local industry on a full cost-recovery basis.

3. The DOE should support special programs that allow women and underrepresented minorities to retrain or participate in internships in energy research, particularly in areas of greatest need to the DOE.

4. The DOE should encourage private companies involved in energy-related businesses 1) to conduct in-house educational programs; 2) to donate equipment to educational institutions; 3) to help local high schools, colleges and universities develop energy-related courses and curricula; 4) sponsor and/or participate in pre- and in-service teacher education programs; and 5) to provide part-time employment to teachers dividing their time between precollege teaching and R&D work.

SUMMARY OF RECOMMENDATIONS

General

The Department of Energy should

1. Highlight the concerns of DOE regarding science education and potential constructive actions taken by the DOE in science education in all appropriate public information presentations.

2. Establish a visible, stable commitment to science and engineering education that funds a spectrum of activities from elementary school through postdoctoral levels.

3. Allocate funds to ensure that scarce resources are appropriately distributed 1) to emphasize DOE's primary educational mission in support of graduate students and postdoctoral fellows, and 2) to augment the support of precollege programs that enhance the quality and enlarge the pool of potential science and engineering students.

4. Establish policies that encourage DOE laboratory staff to participate in educational activities at the national laboratories and in outreach activities that support local and regional initiatives to improve science education, particularly at the precollege level.

Graduate and Postdoctoral

1. The Panel recommends that the DOE continue to emphasize its educational mission primarily in support of graduate students and postdoctoral fellows through university grants and contracts which also serve the research mission of the Department. The recommended level of support should be increased in those disciplines of special importance to the DOE's fundamental science and energy mission.

2. The Panel recommends that stable and predictable funding levels be provided for university-based research projects involving students by making multi-year commitments.

3. The Panel recommends that targeted graduate and postdoctoral research fellowship programs be increased by the DOE in areas of science and engineering of particular importance to energy programs, with particular emphasis given to areas that have limited university research funding. Special targeted programs for women and underrepresented minorities should be established.

4. In the fulfillment of its mission to support advanced education and research, the Panel recommends that the Department continue to focus on quality in its efforts to develop human resources.

Undergraduate

1. The Panel recommends that the DOE increase support of undergraduate students in the Lab-Coop and SERS Programs. Priority should be given to women and underrepresented minority students and to students from institutions having little or no in-house research activities.

2. The Panel recommends that the DOE encourage principal investigators to actively recruit undergraduates as participants in ongoing, DOE-sponsored university-based research programs.

3. The Panel recommends that the DOE support the development of vigorous programs explicitly to attract and retain a larger fraction of underrepresented minorities and women (including those re-entering the field) undergraduates in science and engineering, particularly in areas of greatest need to the DOE.

4. The DOE should maintain at least the current level of support in the Faculty Research Participation Program for faculty from undergraduate institutions, particularly faculty from small, non-research institutions who might not otherwise have an opportunity to participate in advanced research.

Precollege

1. The Panel recommends that the Department establish an infrastructure, a communication network, and a five-year plan to provide stable support for precollege education programs.

2. The Panel recommends that the Department strongly endorse and participate in efforts by the National Science Foundation and the Department of Education to establish graduate fellowship programs for a Masters degree in science education for science/engineering/technology baccalaureate graduates. The Panel further recommends that DOE provide opportunities for future science teachers to participate in laboratory research programs.

3. The Panel recommends that DOE initiate a program for allowing in-service science teachers to divide their time between classroom teaching and participation in DOE (or industrial research) during the calendar year.

4. The Panel recommends that the Department develop formal partnerships, and strengthen existing partnerships, between DOE laboratories, teachers, and state and community organizations dedicated to enhancing student involvement in science, mathematics, and engineering.

5. The Panel recommends that DOE target students who demonstrate high achievement, commitment, or potential in science, and involve these students in formal and informal programs that allow personal encounters between them and working scientists.

6. The Panel recommends that DOE base its precollege programs on the following guidelines which ensure that programs reach the largest number of

students and are most effective in retaining them in science and mathematics education. These guidelines should be either followed or modified, depending on each DOE laboratory's unique strengths and on the successful education programs that are currently in place.

- Concentrate on developing programs for teachers. Emphasize programs that 1) help teachers enhance their science skills and understanding; 2) provide teachers and students with hands-on science activities; and 3) encourage understanding of the relationships between science, technology and society.
- Assess needs involving both educators and scientists in the process.
- Evaluate the effectiveness of ongoing programs.
- Target the grade levels that individual laboratories can reach effectively. Some programs should give special consideration to young students and their teachers at the elementary and middle school levels.
- Develop and support vigorous programs to stimulate and nurture the interest of young women and underrepresented minorities to participate more fully in the DOE education programs in science and engineering.
- Collaborate with educators and researchers to develop instructional materials for taking advantage of state-of-the-art audio-visual aids, computer technologies and other electronic delivery systems, and strategies for exploring relationships between science, technology and society. Efforts in this area should focus on developing materials that can be integrated into or used as a supplement to existing science curricula.

Public Awareness and Continuing Education

1. The Department should provide incentives to its own scientific and technical personnel, as well as those at the national laboratories and universities, to take the initiative in developing energy-relevant adult education programs and working with local school groups to develop parent outreach programs in science education.

2. The Panel recommends that the DOE strengthen continuing education programs for both professionals and technicians at DOE national laboratories and enlarge those programs to permit participation by local industry on a full cost-recovery basis.

3. The DOE should support special programs that allow women and underrepresented minorities to retrain or participate in internships in energy research, particularly in areas of greatest need to the DOE.

4. The DOE should encourage private companies involved in energy-related businesses 1) to conduct in-house educational programs; 2) to donate equipment to educational institutions; 3) to help local high schools, colleges and

universities develop energy-related courses and curricula; 4) sponsor and/or participate in pre- and in-service teacher education; and 5) to provide part-time employment to teachers dividing their time between precollege teaching and R&D work.

APPENDIX A

SECRETARY'S CHARGE LETTER

The Secretary of Energy
Washington, DC 20585

February 19, 1987

Mr. John H. Schoettler
11855 East Daley Circle
Parker, CO 80134

Dear Mr. Schoettler:

The President, in addressing the future of the country in his State of the Union Address, noted the important role science and technology will play in enhancing the future competitiveness of the United States, and the resulting need for excellence in education in preparing for the future. Clearly, there is a need to strengthen the Nation's science-education system if we are to continue our pre-eminence and leadership in science.

The Department is doing much with the education community. In addition to direct support to the university community through research grants and contracts, DOE also makes available such major user-facilities as the National Synchrotron Light Source and supports a number of laboratories, such as the Fermi National Accelerator Laboratory and the Stanford Linear Accelerator Center, which were established essentially to be available to the university community. In addition, in 1985 DOE started a new program of bringing the very best high-school science students for participation in summer research at the world-class research facilities located at DOE laboratories. It is estimated that the total value of DOE support to university research and education exceeds one billion dollars per year.

Yet, with the increasing importance of education and science to the future of the Nation, I want to ensure that the Department is doing all that it should to develop fully the Nation's scientific talent at the pre-college, university and post-graduate levels in order to meet the Nation's future scientific and technological needs.

Therefore, I would like the Board to undertake a study that would review the Department's activities with the education community to ensure that DOE is indeed playing its proper role vis-a-vis other federal agencies and the private sector in the support of scientific and technical education and training. In particular, the Board should address the following key questions:

o Do the current education and training programs of DOE address the right needs and are they effectively coordinated?

- Is DOE taking full advantage of the resources and capabilities of the national laboratories in the support of education and training?

- What responsibilities and mechanisms are appropriate for the Department in the support of elementary and secondary science education, of undergraduate and graduate students, of post-doctoral researchers, and of the general (non-science) public?

- Should the Department provide support for undergraduate and graduate research fellowships in energy manpower areas designated in short supply?

I would appreciate the report by February 1988.

Yours truly,

John S. Herrington

John S. Herrington

APPENDIX B

RESPONSES TO PANEL INQUIRY

APPENDIX B

SUMMARY OF RESPONSES TO PANEL SURVEY

Respondent	Precollege	Undergrad.	Graduate	Faculty	Lab Progrs.	Minority/Women	Public Educ.	Miscellaneous
#1		More DOE support at small insts.				Encourage Hispanic students		
#2	Focus on average students; reach K-6 teachers							
#3	Help stimulate early interest in science		Support grad traineeships, not just fellowships					
#4					Support lab ties with HBCUs	Establish competitive pre/post doctoral minority fellowships		
#5		More funding for u.g. students at labs			More support for lab student res		Lab public educ role	Broaden interpretation of energy ed. to include all S/E areas
#6	Reinstate teacher training insts.	Support more research at u.g. insts.						
#7			Must be vigorous univ. research to attract best students		Labs should not replace univs in educ. of students			Foster educ. in various alternatives of energy production

APPENDIX B

SUMMARY OF RESPONSES TO PANEL SURVEY

Respondent	Precollege	Undergrad.	Graduate	Faculty	Lab Progrs.	Minority/Women	Public Educ.	Miscellaneous
#8	Strengthen teacher training through % of research $	Develop instruc. materials			Focal point of DOE and educ. should be at labs			
#9	Expand targeted group to included broader range of students; expand teacher insts.					Expand minority programs at all levels		
#10	Expand teacher insts.			Need to develop competitive programs for faculty at u.g. schools	Continue use of univ. consortia to interface with DOE labs	Continue focus on minority schools		
#11			Support both u.g. and grad. fellowships					
#12					Provide stronger links between labs and u.g. schools		Public literacy in energy is problem	

APPENDIX B

SUMMARY OF RESPONSES TO PANEL SURVEY

Respondent	Precollege	Undergrad.	Graduate	Faculty	Lab Progrs.	Minority/Women	Public Educ.	Miscellaneous
#13		DOE should recognize important role of junior colleges in preparing students for energy careers						
#14	All levels DOE must take an active role ensuring adequate supplies of prof. manpower	Fellowships needed for both u.g. and grads.	Fund competitive grad. fellowships at 15K/yr.	Expand faculty sabbaticals at DOE labs	Encourage lab staff to become adjunct profs.			Provide excess equip. to univ.
#15				Need more support for young P. I.s				Support currently underfunded colleges/universities
#16			DOE support for grad. fellowships is inadequate to meet national needs; 300 new fellowships per year at minimum					

APPENDIX B

SUMMARY OF RESPONSES TO PANEL SURVEY

Respondent	Precollege	Undergrad.	Graduate	Faculty	Lab Progrs.	Minority/Women	Public Educ.	Miscellaneous
#17			More support needed for grad. fellowships in critical energy fields					
#18			Additional funding for graduate research fellowships					
#19		More support for teacher, student programs; course materials, lectures, summer jobs at labs, etc		Additional faculty research opportunities; teaching excellence awards				
#20	DOE should take lead in support for regional teacher institutes	Summer and co-op opportunities	Re-establish highly visible, competitive grad. fellowships					
#21						Need to assess overall impact of targeted programs		Assess overall impact of all DOE programs

APPENDIX B

SUMMARY OF RESPONSES TO PANEL SURVEY

Respondent	Precollege	Undergrad.	Graduate	Faculty	Lab Progrs.	Minority/Women	Public Educ.	Miscellaneous
#22	Give teachers more opportunity to keep abreast of their fields		Need grants for DOE scientists to serve as visiting lecturers; work with ed. prof. to develop new software					
#23	1) Improve working conditions for teachers 2) Atract better people into teaching 3) Gain concensus of community 4) Improve instruction for average student							

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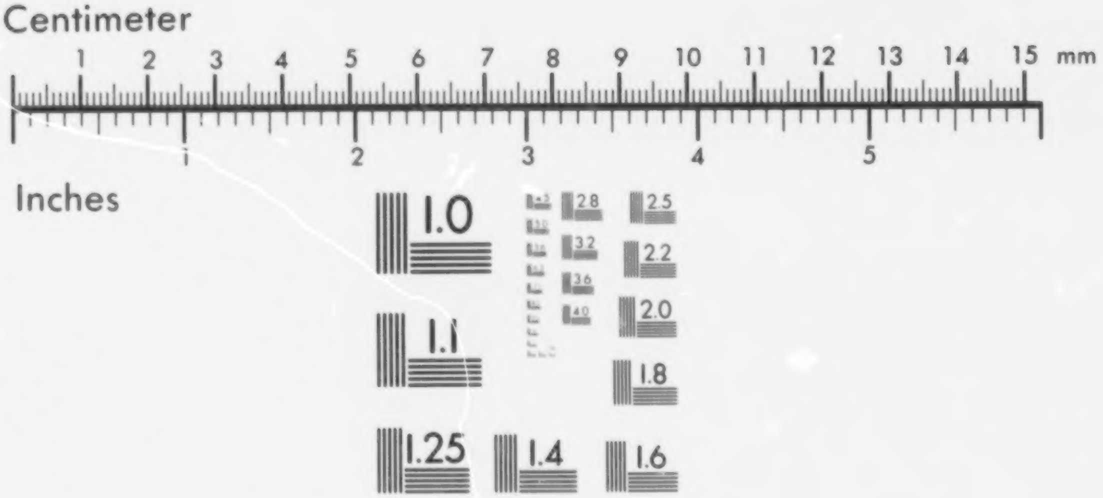
AIIM

Association for Information and Image Management

1100 Wayne Avenue, Suite 1100
Silver Spring, Maryland 20910
301/587-8202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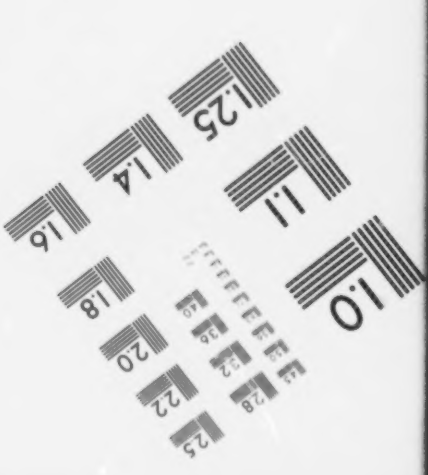

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APPENDIX B

SUMMARY OF RESPONSES TO PANEL SURVEY

Respondent	Precollege	Undergrad.	Graduate	Faculty	Lab Progrs.	Minority/Women	Public Educ.	Miscellaneous
#24	Generally need more programs in this area; superkids institutes cost ineffective	Expand DOE univ.-lab coop prog. to include capable (not only outstanding) students	Continue successful Post Doc. programs at natl. labs	Need support for subbaticals to natl. labs				Improve access to DOE facilities for students and teachers Applauds DOE program that allows students and teachers at extended terms at natl. labs DOE needs to improve fiscal planning for its ed. programs; provide funding stability
#25	An outstanding example of partnership: the Conference on Teaching of Modern Physics, Fermilab, 1986. Lead to development of new curriculum							

APPENDIX B

SUMMARY OF RESPONSES TO PANEL SURVEY

Respondent	Precollege	Undergrad.	Graduate	Faculty	Lab Progrs.	Minority/Women	Public Educ.	Miscellaneous
#26		Should support undergraduate and graduate level seminars		Simplify relationships w/univ. and access to facilities			Broaden outreach programs	Generalize ed. and training programs
		Support undergraduate and graduate researcher fellowships in energy manpower areas	Continue support for post-doc. and research				Extend gen-public outreach programs	Need to coordinate programs better
								Make better use of DOE natl. labs as regional resources
#27	Reinstate teacher workshops in energy areas							
#28						Provide opportunity for minorities other than blacks (hispanics)		Expand scope of environmental programs

Energy Research Advisory Board
to the
United States Department of Energy
1000 Independence Avenue, S.W.
Washington, D.C. 20585
(202) 586-5444

August 18, 1987

Dear :

I am writing to seek your personal views and suggestions on the role and responsibilities of the U.S. Department of Energy in support of the national effort to strengthen the nation's science and technical education system.

By way of background, the Secretary of Energy has asked the Energy Research Advisory Board to undertake a study that would review the education activities of DOE, particularly to ensure that DOE is indeed playing its proper role vis-a-vis other Federal agencies and the private sector in the support of scientific and technical education and training. The Secretary's letter to ERAB, along with a list of the members of the ERAB panel established to carry out this study, are enclosed for your information. Also enclosed is a recent report which includes a summary of current DOE support for scientific and technical education at the precollege and university levels.

As you can see from the Secretary's charge letter, the scope of our study will cover the precollege, university and postgraduate levels with significant attention to the potentially unique contributions which can be made in scientific and technical education by the Department's national laboratories and major contractor research facilities. The panel would sincerely appreciate your personal views and suggestions on any or all of the issues listed in the Secretary's letter. It would be particularly helpful if we could receive your views by September 30, 1987, so that we can prepare a synthesis of the various comments and recommendations in time for the next meeting of the panel scheduled for October 9, 1987.

Thank you very much for your assistance on this vitally important effort for the Department of Energy.

Mildred Dresselhaus
Mildred Dresselhaus
Chairman, Education Panel &
Institute Professor of
Electrical Engineering & Physics
Massachusetts Institute of Technology

Enclosures: List of Panel Members
Secretary's Charge Letter
University Research & Scientific Education
Programs of the Department of Energy

Please address replies as follows:

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Energy Research Advisory Board
ER-6, 3F-043
U.S. Department of Energy
Washington, DC 20585

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APPENDIX C

AGENDAS FOR PANEL MEETINGS

Education Panel
Energy Research Advisory Board
Agenda
August 4, 1987
Holiday Inn, Maple Room
Palo Alto, California

4:00	Convene	
	Introduction of Members and Staff Opening remarks Panel Overview and Charter	Mildred Dresselhaus Chair
4:15	Overview of Current DOE Science Education Programs	Antionette Joseph Director Office of Field Operations Mgt.
5:00	NASA Ames Research Center Education Program	Richard Reeves Associate Director
5:30	Science Education Programs at the Lawrence Hall of Science/Lawrence Berkeley Laboratory	Marjorie Gardner Director Lawrence Hall of Science Roland Otto Associate Director
6:15	Science Education Programs at the Lawrence Livermore National Laboratory	Pat Heth Manager External Relations
7:00	Break for Dinner (The Greenery)	
8:00	Discussion o review of issues o future meeting dates o future speakers o staff studies or surveys requested	Panel Members
9:00	Adjourn	

Education Panel
Energy Research Advisory Board
Agenda
October 9, 1987
Forrestal Building
Room 4A-110

8:30	Convene	
	Administrative Items Survey of Responses to Letters of Inquiry	Mildred Dresselhaus Chair Richard Stephens Director of Industry and Universities Programs U.S. Department of Energy
9:00	Science Education Programs at the National Science Foundations	Bassam Z. Shakashiri Assistant Director for Science Engineering Education
10:00	Break	
10:15	DOE	
	University Consortia Perspectives on Energy-related Scientific and Technical Manpower Development	William Felling Executive Director Oak Ridge Associated Universities
11:15	Current Trends in Students in Science and Engineering	Betty Vetter Executive Director Commission on Professionals in Science and Technology
12:15	Lunch	
1:15	Science Education Programs at Argonne National Laboratory	Robert Springer Director Educational Programs Division
2:15	Discussion	Panel Members
4:00	Adjourn	

Education Panel
Energy Research Advisory Board
Agenda
December 16 and 17, 1987
Battelle Washington Office
2030 M Street, N.W.
Suite 800

Wednesday, December 16

8:30	Convene	
	Coffee and Panelists' Discussion of Meeting Plans	Mildred Dresselhaus Chair
9:00	Department of Education	Lawrence Grayson Deputy Director Postsecondary Relations Office of the Assistant Secretary for Post-Secondary Education
10:00	Council of State Science Supervisors	David Kennedy President
11:00	National Institutes of Health	William Pitlick Research Training Officer
12:00	LUNCH	
12:30	Department of Defense	Ted Berlincourt Director Research and Laboratory Management
1:30	Department of Energy's Follow-up of 1983 Bennett Study	Richard Stephens
2:30	Discussion	Panel Members
5:00	Adjourn	

Thursday, December 17

8:30	Coffee	
9:00	Minority Students in Precollege Mathematic and Science	Cora Marrett Department of Sociology University of Wisconsin
10:00	Science Service, Inc.	E. G. Sherburne Director
11:00	Brookhaven National Laboratory	Nicholas Samios Director
12:00	LUNCH	
12:30	Discussion	Panel Members
5:00	Adjourn	

Education Panel
Energy Research Advisory Board
Agenda

January 12 and 13, 1988
Battelle Washington Office
2030 M Street, N.W.
Suite 800

January 12, 1988

8:30	Working Meeting	Mildred Dresselhaus Richard Stephens Irene Hays

Education Panel
Energy Research Advisory Board
Agenda

January 27, 1988
Battelle Washington Office
2030 M. Street, N.W.
Suite 800

January 27, 1988

8:30	Convene Introductory Remarks	Mildred Dresselhaus Chair
	Discussion of Draft Report	Panel

APPENDIX D

DOE'S CURRENT SCIENCE AND ENGINEERING EDUCATION PROGRAMS

DEPARTMENT OF ENERGY
CURRENT SCIENCE EDUCATION AND UNIVERSITY RESEARCH PROGRAMS: BY CATEGORY AND PURPOSE
FY 1988

PROGRAM CATEGORIES/DESCRIPTIONS	EDUCATION ACTIVITIES	RESEARCH AND RELATED ACTIVITIES	FUNDING LEVEL ($ in 000)	NUMBERS OF PARTICIPANTS
I. INDIVIDUALS/GROUPS				
A. PRECOLLEGE				
1. Minority Student Research Apprenticeship - Summer work assignments at DOE Labs for minority students.	├────┤		$120	200
2. DOE High School Student Honors Research - Program research experiences at DOE Labs for best science students in each state. - Includes emphasis on identifying & selecting women/minority students.	├────	────┤	550	200
3. Prefreshman Engineering Program (PREP) - Summer Institutes for junior high school women/minority students. - Encourage students to pursue engineering or related careers.	├────┤		300	2,000
4. Precollege Science Teacher Research/Training - Summer research/instructional programs at DOE Laboratories for precollege science teachers. - Includes instructional materials development.	├────	────┤	250	60
5. Laboratory Technical Assistance to Precollege Schools - Voluntary assistance provided by lab scientists to strengthen science/math teaching in local elementary/secondary schools.	├────┤		N/A	N/A

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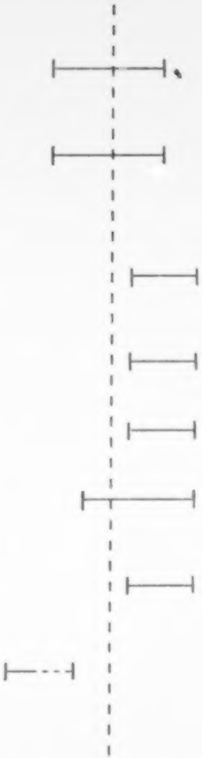

B. UNDERGRADUATE		
1. Research Internships at DOE Laboratories - Summer research assignments for undergraduate students at 30 DOE Labs on research facilities. - Includes emphasis on women/minorities.	1,000	1,000
2. Science & Engineering Research Semester (SERS) - Semester-length research/instructional appointments at five DOE Laboratories for undergrad students selected nationally. - Includes emphasis on women/minorities.	400	120
C. GRADUATE STUDENTS		
1. Research Assistant Support - Support for graduate students working as research assistants on DOE-University research projects.	N/A	2,000-3,000
2. Graduate Research Appointments at DOE Labs - Summer and academic year research appointments.	N/A	2,000 (EST)
D. UNIVERSITY FACULTY		
1. Research Awards - Regular competitive research awards. Minority/women scientists encouraged to compete.	4,100	3,500
2. Minority Institution Faculty Research - Competitive support for faculty members from Historically Black Colleges & Universities. - Support provided by individual DOE program offices.	3,000	45 (EST)
3. Faculty Research Appointments at DOE Labs - Summer and academic year research appointments at DOE Labs & research contractors. Women/minority faculty encouraged to apply.	N/A	200-300
4. Short Courses/Institutes for Faculty - Laboratory - sponsored summer institutes, short courses etc. on energy research topics for faculty encouraged to apply.	500	1,000 (EST)

E. POSTDOCTORAL RESEARCHERS		
1. Postdoctoral Research Appointments - Support for Postdoctoral Research Appointments generally are for two years. Women/minority scientists encouraged to apply.	N/A	400 (EST)
II. INSTITUTIONAL SUPPORT		
A. MINORITY INSTITUTIONS		
1. Minority Institution Research Travel - Support for travel for DOE Labs/other research facilities for faculty members from minority institutions.	300	200 (EST)
2. Cooperative Research Programs with DOE Labs - Includes formal agreements between DOE Labs and minority universities for joint research, technical assistance equipment loans, etc. Current Agreements: ORNL: University of Puerto Rico LBL: Jackson State University LBL: Jackson State University/Mendez Education Foundation, Puerto Rico ANL: Atlanta University ORNL: Atlanta Universtiy LANL: Howard University LLNL: Southern University/Jackson State University PNL: Florida A/M University LANL: SANDIA/ORNL: NM Highlands Univ./NCA&T Univ./Mendez Foundation	N/A	N/A
3. Minority Educational Institutions Assistance Program - Support from the DOE Office of Minority Economic Impact to Strengthen Energy-Related Research and Education Programs at Minority Colleges/Universities Current Projects: Texas A&I Univ.; Howard Univ.; ALA.; A&M Univ.; Atlanta Univ.; Univ. of Puerto Rico, NCA&T Univ.; Univ. of Texas, El Paso, City Univ. of NY.	1,500	8 Projects

III. OTHER			
A. Career Planning Workshops Support for seminars/workshops for women/minority students on careers in science/technology; generally conducted at DOE Labs.	├────┤	N/A	600 (EST)

APPENDIX E

DOE'S PRECOLLEGE EDUCATION PROGRAMS

Appendix E

Survey

DOE Pre-University Education Programs
November 1987

Responses

Facility	Contact
X - Allied Corporation. Bendix Kansas City Division	Kathy Bien
X - Argonne National Laboratory	Juanita Thomas
X - Associated Western Universities	Melanie Russell
X - Bates Linear Accelerator Facility	William Lober
X - Brookhaven National Laboratory.	Donald J. Metz
X - Center for Energy and Environment Research	Carlos Maysonat
X - Environmental Measurements Laboratory	G. de Planque
X - Fermi National Accelerator Laboratory	Marjorie G. Bardeen
X - Lawrence Berkeley Laboratory.	Lucy Day
X - Los Alamos National Laboratory.	Judith Kaye
X - Mound Facility, Monsanto Research Corporation	Howard Charbeneau
X - NORCUS.	Brian Valett
X - Oak Ridge Associated Universities	Yvonne Sanders
X - Oak Ridge National Laboratory	Linda Cain
X - Pacific Northwest Laboratory.	Irene D. Hays
X - Paducah Gaseous Diffusion Plant	Debbie Wattier
X - Pantex Plant, Silas Mason Co., Inc.	G.L. Curtis
X - Princeton Plasma Physics Laboratory	Harold Furth
X - Sandia National Laboratory.	Ralph Bonner
X - Savannah River Laboratory	Janell Gregory
X - Solar Energy Research Institute	Joan A. Miller
X - Stanford Linear Accelerator Center.	Helen Quinn
N - Ames Laboratory	Daniel William
N - Inhalation Toxicology Research Institute.	Roger McClellan
N - MSU-DOE Plant Research Laboratory	Karen Kline
N - Notre Dame Radiation Laboratory	John Bentley
N - U.S. Department of Energy, Morgantown	Wennona Brown
C - Coal Fired Flow Facility.	Charles Lee
C - Hanford Engineering Development	Dorothy Hansen
C - Idaho National Engineering Laboratory	William Toth
C - Lawrence Livermore Laboratory	Ron Teunis

X = Response; C = Contact, no response; N - No programs

Appendix E

Targeted Audiences for Precollege Programs

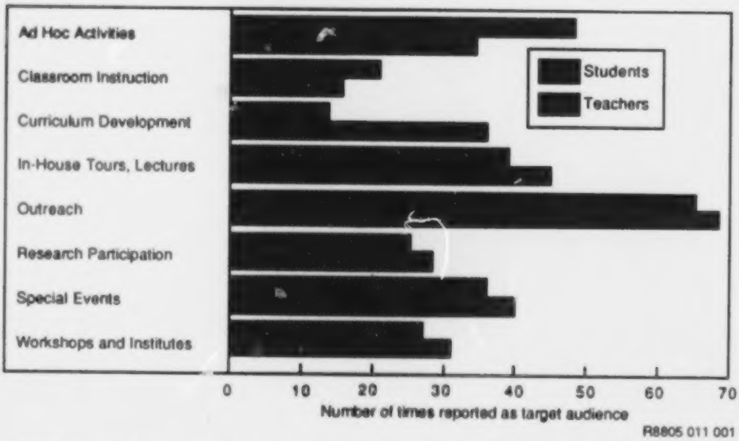

Figure 2. Targeted audiences, whether students or teachers, were noted for components in 195 programs reported from 21 facilities. Any one program component may target both students and teachers.

Appendix E

Goals of Precollege Programs

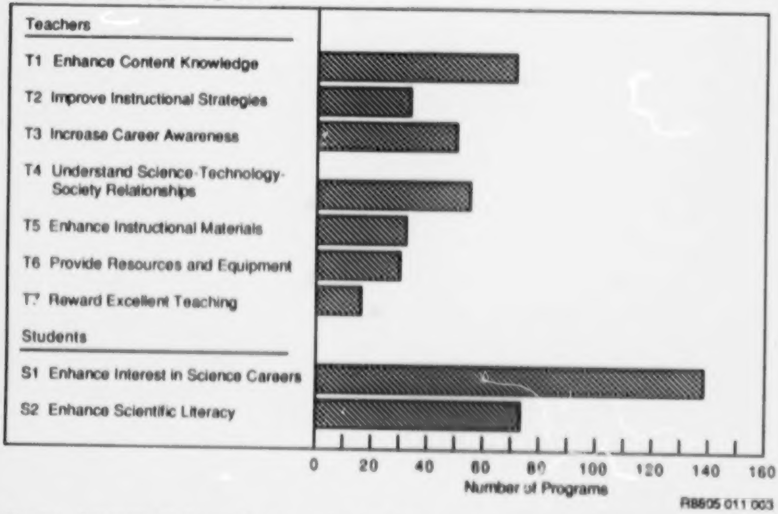

Figure 1. The goals of 195 precollege programs at 21 DOE facilities were reported. Any one program may fulfill more than one goal.

APPENDIX F

STATUS OF RECOMMENDATIONS FROM PREVIOUS OVERSIGHT

ENERGY RESEARCH ADVISORY BOARD
ASSESSMENT OF DOE-UNIVERSITY RELATIONSHIPS (AUGUST 1983)
STATUS OF RECOMMENDATIONS

MAJOR ISSUES/RECOMMENDATIONS	DOE ACTION TO DATE
I. DOE Policies Regarding University Support	
A. DOE should develop agency-wide R&D planning processes.	Agency-wide R&D planning process has been under review for three years. Proposed Agency R&D Coordination Council would provide guidance to programs in preparing long range R&D plans. Opportunities would be provided for external reviews of plans.
B. Expand existing system of advisory panels.	Several new DOE program advisory committees have been added since 1983 including Basic Energy Sciences and Health and Environmental Panels. University scientists are included on all existing advisory panels. New policy directive on proposal review procedures/standards under development.
C. Concentrate support for Historically Black Colleges and Universities (HBCUs) in a few competitively selected institutions.	DOE support for HBCUs has increased every year since 1983. Institutions with science/engineering capabilities have been particularly successful. Nine formal collaborative programs exist between HBCUs and DOE labs.
D. DOE should issue agency-wide policy statement defining role of universities in DOE programs.	Policy statement on DOE-university relations issued by Secretary Hodel in August, 1984, and reaffirmed by Secretary Herrington in January, 1986. Statement includes guidance on support for students, joint university-lab programs, stability in university funding, etc. ER has agency-wide monitoring function.

MAJOR ISSUES/RECOMMENDATIONS	DOE ACTION TO DATE
II. DOE Management and Procurement Policies and Procedures	
A. DOE should review the appropriateness of the university proposal review procedures used by each DOE office.	Proposal review procedures were evaluated in 1984 and procedures used by each program were summarized in the DOE Program Guide.
B. DOE should strongly reaffirm importance of unsolicited research proposals.	Unsolicited research proposals remain the principal mechanism used by DOE to support university research.
C. Universities should normally deal with only one DOE field office for all DOE contracts/grants.	This recommendation was extensively studied and a decision made to retain the current regional focus for university awards. Chicago normally handles about two-thirds of all DOE research awards and continued efforts are being made to ensure consistency in execution/monitoring of university awards by the various field offices.
D. Grants and multi-year research awards should be used to support university research.	Extensive use of research grants to support university research began in 1985. Research grants are multi-year.
E. Periodic meetings should be held between university administrators and DOE procurement staff to resolve problems.	Regular meetings were held between DOE and university staff beginning in 1985 with many issues resolved. Meetings are now held as necessary.
III. Relationships Between DOE Laboratories and Universities	
A. Laboratory research proposals should be subjected to the same standards of peer review as university research proposals.	ER conducted an in-depth review of procedures used by both the labs and DOE program staff to review new research proposals from labs. Extensive use of scientific advisory committees by the labs was noted. DOE has issued regular guidance to the labs on criteria for considering new research work. Annual on-site institutional reviews of each lab includes evaluation of proposed new research.

MAJOR ISSUES/RECOMMENDATIONS	DOE ACTION TO DATE
B. Laboratories should have greater discretion in a allocation of resources and in selection of performers.	Continuing reviews are made of DOE policies/procedures for reviewing laboratory work including provisions for subcontracting. In general, the labs have significant flexibility in deciding how to allocate resources and/or to involve subcontractors including universities.
C. DOE should encourage laboratories to develop collaborative research programs with universities and industry.	Secretary's policy statement includes guidance to labs on joint research programs with universities and industry. A number of collaborative programs have been developed with universities; fewer with industry although recent emphasis on stimulating laboratory technology transfer may change this.
D. Significantly expanded support should be provided for laboratory-based faculty and student research/education appointments.	Since the ERAB report was released in 1983, DOE support for laboratory education programs has increased from $5.5M to $12.3M. New precollege science programs have been instituted and five of the ER multiprogram labs have been classified as Science Education Centers providing support for a range of faculty and student programs including academic semester appointments for undergraduate students and faculty/student team research during the summer.
E. Annual laboratory institutional reviews should include evaluation of each laboratory's relationships with the university community.	The annual institutional plan and on-site reviews for each laboratory includes discussion and evaluation of laboratory-university interactions including joint research programs, support for summer and academic year appointments for faculty and students, etc.
IV. University Participation in Energy Technology R&D	
A. Each DOE technology program office should support university research related to programmatic needs.	The ERAB Panel was concerned about the relative imbalance in university funding from DOE with over 80% of total university funding provided by the Office of Energy Research. University funding from the energy technology programs has not grown appreciably since the ERAB report principally due to budget limitations. The Office of Fossil and Nuclear Energy have attempted to increase support for university research but at relatively low levels.

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MAJOR ISSUES/RECOMMENDATIONS	DOE ACTION TO DATE
B. The ER Engineering Research Program should be significantly increased in size and scope.	Increased funding has been provided to this program since 1984 including support for an innovative joint laboratory-university research program in fundamental engineering research, involving MIT and the Idaho National Engineering Laboratory.
C. Increased support should be provided for competitive graduate fellowships in engineering disciplines specifically including nuclear engineering.	Support is provided for 75-88 graduate research fellowships per year in nuclear engineering and fusion technology. The FY 88 Senate/House Appropriation Bill for DOE also includes $10M to initiate a new research and graduate education program in nuclear engineering including at least 30 graduate fellowships per year. DOE technology programs have the authority to support graduate fellowships in their respective mission areas.
V. DOE ROLE IN THE DEVELOPMENT OF NEW PROFESSIONAL MANPOWER	
A. DOE should explicitly recognize its obligation to play a significant supporting role in the overall national effort in technology education.	The ERAB Panel strongly supported an expanded role for DOE in scientific manpower development including fellowships, postdoctoral researchers and precollege programs. The Secretary's university policy statement explicitly cites the importance of DOE support for students. Funding for precollege and college level student programs at the DOE labs has substantially increased since 1983. Policy level endorsement for an increased DOE role in manpower development and education has been provided by both OSTP and OMB.
B. DOE should initiative an agency-wide graduate and postdoctoral fellowship program.	Consideration was given to reinstituting an agency-wide graduate research fellowship program but the decision was made to support such fellowships through individual DOE program offices where there was a clearly identified manpower need. Postdoctoral appointments are provided through the individual labs except for the agency-wide Hollender Postdoctoral Fellowships in Environmental Science.

MAJOR ISSUES/RECOMMENDATIONS	DOE ACTION TO DATE
C. Increased emphasis should be placed on attracting more women and minority students into the national SAT manpower pool.	DOE supported education and manpower development programs include specific emphases on attracting/supporting women and minority students. One program, the ER Prefreshmen Engineering Program (PREP), focuses on junior high school women/minority students. Other programs tend to concentrate on students "already in the pipeline."
VI. COMMUNICATIONS BETWEEN DOE AND THE UNIVERSITY COMMUNITY	
A. DOE should establish a similar university forum to the successful "DOD-University Forum" to advise on DOE-university relationships and concerns.	A proposal was made to and accepted by Secretary Hodel to set up a "DOD-University Forum." However, subsequent concerns over the number of DOE advisory committees led to a decision not to proceed with the Forum. University scientists are actively involved in all current DOE scientific advisory committees including ERAB. The need for an additional advisory committee focused on university concerns is periodically reviewed by ER.
B. DOE should improve the dissemination of information to universities about DOE research needs, programs, interests and facilities.	A comprehensive DOE Guide to Programs was published in 1984 and will be reissued in 1987 with subsequent publication on biennial basis. An on-line computerized data base on DOE programs is also under development as a companion to the Guide to Programs.

Ms. **Lloyd**. Thank you very much, Toni. I do want to congratulate the Department of Energy and certainly express my appreciation to Secretary Watkins, because he indeed is putting greater emphasis on our educational programs. As a note of interest, Admiral Watkins was a student at Oak Ridge and he says at this time that he really just decided he wanted to stay in engineering, that he wanted to pursue his studies in nuclear engineering because he was really motivated while at Oak Ridge to go on and pursue greater excellence in his education. And that certainly speaks well for what we do at Oak Ridge.

But I think at the same time that we do need to put science education on a higher priority with greater visibility and I would like to get your comments on science being perceived as a basic skill. Are we doing enough to elevate science to its proper role as we approach the 21st century?

Ms. **Joseph**. I serve for the Department on a Task Force on Women, Minorities and the Handicapped, and I think that experience and the hearings across the country, as well as the inter-governmental meetings that have occurred since then, show that there really is a focus on just that area.

There is an effort also on the Administration looking at technology transfer and looking at what initiatives might be taken in technology transfer. And one of the subgroups of that effort is a human resources subgroup that will look at that component in science education, training of students and improvement of the science education system to provide a better science and engineering foundation for students that will become the work force of the year 2000.

So I think there is, in the last two years at least, some significantly increased effort in just that area.

Ms. **Lloyd**. I think we need to say at the very beginning, we are not here to put down our educational systems or our teachers, our educators, in any way. We want to see what we can do to help the educational system, the role of the National Laboratory, the role of the private sector, the role of the Federal Government in not only improving the quantity, but the quality of science education, that we are here to help and certainly not to put down.

I am concerned about the number of students that are getting into the program. Are we attracting the top third, the top half—where are we really focusing in on the young people?

Ms. **Joseph**. In the DOE programs, there is an emphasis on the top 25 percent of the students in each of the program areas. This is true for the high school honors program, that is even a smaller segment, probably the top 10 percent. In the lab co-op and in the other undergraduate and graduate programs, we are talking about students who have grades that are in the top 25 percent. In addition, we have several targeted programs which are aimed, just as you say, not to replace the science education system, but to support it through enrichment programs. The prefreshman engineering program is an example of that for minorities and women in seventh through tenth grades, and that focuses on students with relatively high grades, but more importantly with an interest in aptitude and science, and the enrichment part of it is focused primarily on improving their math skills.

We also have a number of outreach activities which you will hear about in great detail, and these activities focus, across the board at all levels of student interest in the sort of turning on part of science, the magic of science in the early years, but also aimed at families and parents and the general public in creating a more supportive environment for students to be interested in, to fear less, science and math and to see the enjoyment and the excitement of science and math.

So the Department, actually through its laboratories, covers the gamut but, in fact, does emphasize the top 25 percent of the students coming out in its major support program.

Ms. **Lloyd**. I have one final comment and then I am going to give the microphone to Congressman Schiff, but this troubles me because I think it is important that we not only define who our scientists and engineers will be, they are not all going to come from the top 20 percent. I think we need some programs for the average students and I think we do need to put greater emphasis on the programs for minorities, for women, because there are a lot of young people that need to be motivated, that really need to be turned on by science and I do not think they are necessarily always in the top 20 percent.

I think as we look at our mission, redefine our mission, that maybe we ought to broaden the base of our support of programs for those that may not be in that top 20 percent.

Thank you. Congressman Schiff.

Mr. **Schiff**. Thank you. Ms. Joseph, thank you very much for coming today.

There is just one area I would like to ask about. I enter into the Science, Space and Technology Committee with a notion that of the groups you have even named, I think the group that is most left out is women, and I base that on the idea of stereotypical effect. In other words, men are pilots, women are stewardesses; men are doctors, women are nurses and all that. I am a lawyer by training and profession and I can tell you that the University of New Mexico Law School, when I graduated in 1972, was three percent women, today it is 52 percent women. The University of New Mexico Medical School is probably up to about 20 percent women now.

I just wonder in the area of science and technology, and I know that is a rather broad question, but are we turning around there? I mean, are young women students convinced that they can also be physicists, mathematicians and chemists or are there still mind blocks here to that?

Ms. **Joseph**. I recommend one report that has recently come out, it is called *Everybody Counts* and it is from the National Research Council, with the emphasis on the importance of mathematics in science education. And one of the areas that I think they do an excellent job on is on looking at the problems that women face very early in their education of stereotypical attitudes toward women in mathematics.

I think the programs—and we helped fund the project *Everybody Counts*—the programs that they recommend, including things like family math and real family orientation, to take away these stereotypes, are things that are needed. They have a kit that goes out to the PTAs in the schools to help start removing some of those stereotypes. I think those kinds of things will take a long time, but I think that, just as medicine and law have changed in terms of the participants, so have there been increases in the pipeline for women particularly and for minorities in the last decade in science and engineering. Women, of course, are going to soon make up the majority of students in higher education if the demographic data continues the way it looks, and a significantly higher portion of women did enter the science and engineering pipeline over the last 15 years. I think it might have gone from 15 to 30 percent. But all of those trends, I am sorry to say, have leveled off, and, in the case of minorities, have begun to dip down.

And if you look at that as the resource for 90 percent of the new entrants into the work force being women, minorities and immigrants, it is clear that much more needs to be done to continue to attract them into the pipeline and to keep them in the pipeline. And my guess is that programs in mathematics enrichment should probably be one of the focal points, all the way from the earliest grades through the programs that we have in the Department of Energy as well.

Mr. Schiff. I would just like to make the observation that this is a difficult area, because on the one hand we can't ignore the lack of equal opportunity from whatever cause for certain groups—and like I say in my opinion, especially women in this area. At the same time I am not a believer in quotas, I am not a believer that a certain number of slots should be kept open in, say, a National Laboratory for people just because of their background in any way, shape, or form. And I think you said the key word, it is pipeline. I think the way to achieve ultimately equality and equal opportunity is to, for special efforts to attract the brightest people from all groups, but especially from these groups, into the pipeline so that they will become, by virtue of their own talent, our top scientists, mathematicians, and so forth.

Thank you very much.

Ms. Joseph. Thank you.

Mr. Schiff. Thank you, Madam Chairman.

Ms. Lloyd. Thank you very much, Toni. We appreciate your participation and for being with us, and we appreciate the good job you are doing, and again our best wishes to Admiral Watkins and tell him that we appreciate his initiative and his interest in science and engineering education.

Ms. Joseph. I will do that, Madam Chairman; thank you.

Ms. Lloyd. On our first panel today, we have Dr. Alvin Trivelpiece, certainly a good friend of this Committee, and we are delighted that he is now the Director of the Oak Ridge National Laboratory, he is a great scientist; Dr. Robert Springer, also of equal accolades, who is with Argonne National Laboratory—we have an all star cast today—and Dr. Manuel Perry of Lawrence Livermore National Laboratory and Mr. Bill Willis, Executive Vice President of the Tennessee Valley Authority. Let me just say, of course, that TVA is not a National Laboratory, it is a Federal agency and certainly a great resource that we have here. They have a great contribution to the subject that we are discussing today.

It is always a pleasure to be with you, Dr. Trivelpiece, and we look forward to your testimony. I would like to again remind you that all of your complete written statement will be made a part of the Congressional Record and you may proceed and summarize as you wish.

PANEL 1

STATEMENTS OF DR. ALVIN W. TRIVELPIECE, DIRECTOR, OAK RIDGE NATIONAL LABORATORY; DR. ROBERT W. SPRINGER, DIRECTOR OF DIVISION OF EDUCATIONAL PROGRAMS AT ARGONNE NATIONAL LABORATORY; DR. MANUEL PERRY, HUMAN RESOURCES PLANNING AND DEVELOPMENT, LAWRENCE LIVERMORE NATIONAL LABORATORY; AND DR. WILLIAM F. WILLIS, CHIEF OPERATING OFFICER, TENNESSEE VALLEY AUTHORITY

Dr. TRIVELPIECE. Is this the auditorium microphone here?

Ms. LLOYD. I think we are limited with microphones today and we are going to have to share a little bit. Please proceed.

Dr. TRIVELPIECE. Thank you, Madam Chairman, it is really a pleasure to be here. Mr. Schiff, nice to see you.

I want to congratulate the Committee on having a hearing on this subject. I think this is very important to do. It is sort of traditional to say it is always a pleasure to be here, there have been many times for the Administration when I have testified under circumstances in which the Congress was displeased with some aspect of the Administration's performance or activity and although you say it is a pleasure, it is not quite. In this case, it is not only a pleasure, it is really a joy. I am pleased to be here.

Ms. LLOYD. You know, we cover a lot of ground, but I think this is a new day for the Department of Energy with greater emphasis on science and engineering education, and I am just thrilled to death, may I say, with the new Secretary. I think he is doing a good job and I think it is going to be a good four years anyway.

Mr. SCHIFF. Excuse me, Doctor—I assure you I will not make a habit of this, Dr. Trivelpiece, but I just wanted to add that I have had an opportunity to sit down with Admiral Watkins to discuss matters personally with him, and I just want to echo that. I think President Bush's selection was very fine in this case.

Ms. LLOYD. Please proceed.

Dr. TRIVELPIECE. You have my prepared statement, as you indicated, it will be in the record.

Ms. LLOYD. Without objection, your entire statement will be made a part of the record.

Dr. TRIVELPIECE. And it has a lot of details in it and I am not going to try to cover all of those details. Toni has covered some and of course the AEC and proceeding through the Department of Energy has had a rather remarkable effect on the educational world, and I only want to add a few things.

You mentioned that Admiral Watkins had attended the school at Oak Ridge and that he had benefited from that. I have had the experience of going all over the United States and all over the world and having people say that I attended the something or other school at such and such a laboratory, or I received a grant from the Division of Nuclear Education and Training from the AEC, and I was greatly distressed when during the Nixon Administration, for reasons that people thought our supply of scientific manpower was too high, that many scholarship and fellowship programs were cut back, and that program in the AEC at that time was terminated. I thought then it was a mistake, I still today think it was a mistake then.

The Department has a lot of programs, and so does the Laboratory, but before starting this, I would like to acknowledge Linda Cain, who is accompanying me here today from the Laboratory, who is the individual that in fact gets the work done on many of the Laboratory programs.

We have programs for everyone, in the sense of adults and teachers. We have an activity that involves ecology and the physical sciences, and this takes place out at Freels Bend at the site where the graphite reactor was. As you know, that's now a historical site and it is a facility where teachers and students and adults can come. It involves K through 12 activities, each unit is a half day, it involves such things as superconductivity, the geology of east Tennessee, how predators go after each other—such things. So it has been an interesting opportunity for a wide collection of people to have some involvement.

Toni Joseph mentioned the PALS program, the Partnerships in Science at the Laboratory, started in 1988 and involves a memorandum of understanding between Oak Ridge National Laboratory and the Oak Ridge Schools. It involves speakers becoming involved in high school and equipment loans and so on.

We also have programs for students all by themselves, pre-college students. There is an activity which goes under the acronym of SEED, Summer Educational Experience for Disadvantaged. It was started by the American Chemical Society. They have had about 2,000 students go through this, this is the second year that this has been at Oak Ridge and we expect about seven to eight participants, and it involves a ten-week program in which juniors and seniors are involved in it and it is a $1,000 stipend, half of which comes from the American Chemical Society and half of which comes from donations. And as I said, that is primarily for the disadvantaged students.

There is a local honors program started in 1986, involves high school students in the Oak Ridge area, some 20 students have been involved. This does not have a regular formal clock associated with it, but it rather anticipates whenever students are available, members of the Lab are available and it is a matter of mutual interest, and so we are prepared to do that.

On a national scale of course, as Toni mentioned, we are involved with the teacher research associates. There are 13 teachers at the Oak Ridge National Laboratory, they spend something like eight weeks there. This is a program which I have watched while I was at DOE from the various Laboratories, and I think they have done a superb job. Berkeley has, with a lady by the name of Peggy Carlock, who is involved in the National Science Teachers' Association, has made a remarkable turnaround in some of the areas in schools in the Berkeley vicinity.

There is a high school honors program and, as Toni indicated, that did get started during the time I was at DOE. And I know you have complimented Admiral Watkins, I think it is also important to realize that the past three Secretaries, although they have perhaps not been as vocal, have in fact been interested in this subject, beginning with Secretary Edwards and Secretary Hodel and certainly in this case, this program owes its existence in great measure to Secretary Herrington, who the very first time when I began to brief him for his confirmation hearing, said can we do anything with the national laboratories to inspire youth to consider careers in science and engineering. I thought he was joking and I thought it was the new boss just with a new line. He in fact kept it up, and it was through his insistence that we ended up suggesting that 50 students, one from each State, in computer sciences go out to the Lawrence Livermore Laboratory and work on the Cray for two weeks, and I still remember with some fondness when I called the Director of the Laboratory at that point and asked him what he thought of having 50 high school kids running around Livermore Laboratory for the summer working on the Cray, you could hear his heart stop beating at the other end of the telephone line.

The reason that I mention that is that I think the Lab was somewhat apprehensive in having them there and perhaps even a little bit resistive. That resistance changed from that to enthusiasm to do it again the next year. And part of the reason was the Laboratory scientists with whom I talked said that one of the more important things was it changed them as much as it changed the students, that having bright young students around asking questions, even though they were in high school, was an important ingredient for the lab, and they would want to continue doing it even if the Department did not.

Another thing that I found fascinating is I had the good fortune to go out and meet these young students during that first summer, and you might well expect they were impressed with the opportunity to get to meet a Nobel Prize winner, they were impressed with the Cray, they were impressed with the other experiments at Livermore, they were impressed with the staff. But you probably would not guess the thing that impressed them the most. And rather than ask you to answer this rhetoric question, I will answer it for myself. What impressed them most was each other. It was the first time in their lives that these young students had had contact with individuals of their age who were as smart as they were. These were some of the very best in the nation. They immediately formed a computer network so that they could communicate with each other by teletype and the like, and they have since maintained some contacts. Seventeen of them went back to Livermore the very next year to work there at the Laboratory again. I am sure that this will pay rich dividends 10, 15, 20 years from now. This same group of young students will have networked with each other and will have maintained this kind of contact.

The DOE labs can do a lot more. I think this is the main point that I want to get across. The situation is not saturated. Very little money and a little bit of volunteer time goes a very long way and by no means are the laboratories overrun with or saturated with students. This could in fact be expanded I think very, very effectively. Things are done for postdoctoral students, for graduate students, for undergraduate students, for high school students, for adults. It involves institutions such as the Oak Ridge Associated

University who I guess you will hear from later, Southeastern University Research Association, historically black colleges. We have relationships with the University of Tennessee at Knoxville and the—you had mentioned earlier this distribution problem, and of course it is true that something like 20 million new workers will be here in the year 2000 and that something like 82 percent of them will be female, non-white and immigrant.

The DOE is as much a consumer of talent as it is a producer of talent. The DOE will not be able to continue its work, as you know there is something like 115,000 employees in the Department of Energy and its laboratory and weapons and other complexes and probably 30,000 of those are scientists and engineers, a very large number. So it is I think a responsible position for the Department to take to try to help contribute to the pool of such talent in addition to being one of the consumers of the talent.

I know for sometime your now departed colleague, Mr. Wydler, was always interested in technology transfer and pushed hard, and there is a bill that bears his name, Stevenson-Wydler. He was interested in tech transfer and how the laboratories can be better used to get patented things out. Those are things that you can keep score on, patents. But I submit that the kind of investment that we are talking about here in young students, is also tech transfer. The time reach may be very long; 10, 15 or 20 years and ability for you and others in the government to keep score and say well yes it has occurred because there have been this many patents may be more difficult, but this is really tech transfer. I believe it is very important.

Once again, Madam Chairman, I congratulate you on having this hearing and I would be prepared to answer any questions.

[The prepared statement of Dr. Trivelpiece follows:]

THE ROLE OF NATIONAL LABORATORIES IN SCIENCE EDUCATION

Alvin W. Trivelpiece

Director

Oak Ridge National Laboratory

Testimony Before the

Subcommittee on Energy Research and Development

Committee on Science, Space, and Technology

May 15, 1989

TESTIMONY
SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
May 15, 1989

Alvin W. Trivelpiece
Oak Ridge National Laboratory

Madam Chairman and Members of the Subcommittee, I am pleased to have the opportunity to testify before this Subcommittee to present my views on science education and the role of the Department of Energy's (DOE) National Laboratories. Although this is not my first appearance before this Subcommittee, I look forward to the occasion since the topic of science education is one which has assumed critical importance to our nation. It is also an area in which I have had a long-term personal commitment having spent much of my adult life involved in science education. For nearly twenty years, I taught at the university level and while at the American Association for the Advancement of Science (AAAS), I was actively involved in educational activities. The organization of my testimony will provide a brief historical perspective of DOE involvement in education at the National Laboratories, a rather general overview of post high school programs at Oak Ridge National Laboratory (ORNL) and highlights of several successful undergraduate research programs carried out at National Laboratories. I intend to focus my attention on precollege programs, discussing in some detail several precollege initiatives at ORNL. I greatly appreciate your interest and concern and anticipate a most worthwhile hearing.

Historical Perspective

DOE has a long history of involvement in education from its beginning in 1946. When one considers that DOE National Laboratories are major employers of scientists and engineers, the interest by DOE in education is most logical. In fact, it would not be an exaggeration to say that DOE has a vested interest in education, particularly in the areas of science, engineering, and mathematics. To quote Secretary of Energy Watkins, "I know that the Department of Energy's National Laboratories are home to some of the world's brightest and most innovative scientists and engineers. These creative minds are a precious asset and will be encouraged not only to continue their basic research, but also to improve the process by which new technologies are transferred to American industries, small businesses, and universities." Historically, the involvement in education has been focused in higher education with emphasis on research appointments at the faculty and post doctoral level. Eventually, undergraduate programs were developed which also focused on research opportunities for students. While educational activities at the National Laboratories are funded in a variety of ways, the bulk of the funding for educational programs comes through the Office of Energy Research (OER).

The educational links between the laboratories and academic institutions are seen as beneficial to both in that: (1) faculty, students, and staff scientists have access to research facilities that may not be available at the base institution and contribute to the on-going research at that guest facility; (2) faculty, students, and staff scientists interact with professional personnel beyond that of the base institution; and (3) students participating in research programs provide an "experienced pair of hands" and a pool of capable students to be encouraged to pursue graduate degrees or to consider employment at the National Laboratories.

From the formation of the Atomic Energy Commission (AEC) in 1946 through a restructuring in 1974 to the Energy Research and Development Administration (ERDA) to its present status as the Department of Energy, initiated in 1977, the involvement with education has been remarkably consistent over time. In fact, it is interesting to review Institutional Plans (IPs) for ORNL during these earlier times and note the similarity of goals to those expressed in the current IP. The goals, quite consistent from 1976 through the present, excluding reference to precollege activities which did not appear until 1987, include an emphasis on the importance of an adequate supply of scientists for the future and a need to expand opportunities for minority participation.

Programs For Post High School Students at ORNL

The laboratories do an excellent job with existing programs in interacting with college and university students and faculty. At ORNL, various methods are used to recognize and document such interactions. About 1000 university-based researchers, supported in a variety of different ways, are housed annually at ORNL. In FY 1988, there were over 250 subcontracts with over 100 different colleges and universities and over 5000 university-conducted experiments with our "user facilities," (research facilities available for shared use). There are many other long standing, close collaborations between ORNL and individual universities that are based on mutual research interests. These collaborations support research programs at such prestigious colleges and universities as Massachusetts Institute of Technology, University of Illinois, University of California at Berkeley, University of California at Santa Barbara, and Duke University. These collaborations often involve active exchange of students and faculty while carrying out research of mutual advantage. While ORNL has joint activities with educational institutions on a national and international basis, at the same time, a special relationship does exist with the University of Tennessee at Knoxville (UTK). This special relationship includes: extensive interaction between both staffs; involvement on advisory boards of both organizations; and the Science Alliance, a memorandum of understanding (MOU) sponsored by the State of Tennessee which encourages joint collaborative research between ORNL and UTK. The Science Alliance is highlighted by the Distinguished Scientist Program, which seeks to attract scientists and engineers of high national and international stature who then have joint appointments at both UTK and ORNL. There are also several specialized UTK graduate programs (Oak Ridge Graduate School of Biomedical Sciences and Graduate Program in Ecology) located at ORNL, as well as the UTK Graduate Program located in Oak Ridge which offers evening courses to those pursuing advanced degrees in scientific and engineering disciplines.

Over 250 post high school students and faculty took part in research-based programs at ORNL in FY 1988 through the Office of University and Educational Programs. The various research-based programs, many a cooperative effort with Oak Ridge Associated Universities (ORAU), a consortium with whom ORNL has a long and successful relationship, span the academic level of programs supporting undergraduates to those supporting faculty research. The goal of DOE for these programs is to help ensure adequate supplies of technical personnel for its future research mission. These programs have been monitored and facts exist which suggest that the goals of these programs have been met.

Minority Programs at ORNL

Existing laboratory programs are also proving successful in increasing the involvement of minorities in laboratory opportunities. Money committed through subcontracts to minority educational institutions (MEIs) has increased by over 40 percent from FY 1987 values. Memoranda of Understanding with five MEIs were established in FY 1988 with the goal of increasing participation with those institutions. A unique pioneering science and technology alliance involving three National Laboratories, including ORNL, and three minority educational institutions, was established by DOE in 1987. Since that time, the Alliance has been successful in improving opportunities for minority involvement at the participating National Laboratories. Through an equipment loan program in FY 1988, over $112,000 worth of equipment was loaned to four MEIs. Eleven Field Work Proposals (FWPs) were established to provide continuity of support with projected award commitments of over $3.3 million through FY 1991.

There are several new initiatives recently announced by Dr. Herman Postma, former Director of the Laboratory and currently the senior vice president at Martin Marietta Energy Systems, Inc. These new initiatives address the need to affect in a positive way the number of minority teachers in Tennessee. There are three distinct new initiatives proposed by Dr. Postma. The first initiative has the goal of increasing the number of black teachers employed by the Oak Ridge schools through summer employment opportunities at the Oak Ridge facilities. The second initiative calls for the expansion of the existing co-op program to accommodate not only students planning on careers in science and engineering, but also including those planning on teaching careers in those areas. The third initiative is similar to the co-op program in that summer-hire positions will be expanded to include individuals whose career plans are focused on teaching in science and engineering areas. While the overall focus of these new initiatives is to increase the pool of black teachers in Tennessee, these initiatives also provide an expanded opportunity for all teachers particularly those in the areas of science, engineering, and mathematics. (Information concerning educational programs at ORNL can be found in Appendix A which consists of the relevant material excerpted from the Oak Ridge National Laboratory Institutional Plan: FY 1989-1994.)

Undergraduate Research Programs

There are several programs which support research experiences for the undergraduate. Some of these programs are for students working toward an associate degree while others are for students aiming, at least initially, toward a baccalaureate degree.

Student Research Participation (SRP)

Let us consider in detail one undergraduate program, the Student Research Participation Program (SRP), a summer research participation program for undergraduate students in which many research facilities, including ORNL, serve as hosts. To highlight relevant points, it can be documented that in 1987, 58 percent of students participating as SRPs from the years 1979-82 have received advanced degrees while 42 percent expect to receive Ph.D.s. Most of those who had completed the Ph.D. said the program influenced their decision to attend graduate school. An important fact in light of demographic studies concerning the changing nature of the future work force, is that females, more than males, reported that participation in the research experience had an influence on their decision to attend graduate school. It is important to recognize that the SRP Program involved students from all 50 states, Washington, D.C., and Puerto Rico. It also included appointments at 40 different host laboratories across the United States. DOE laboratories, while all involved in energy-related research, vary in many ways. Laboratories may be managed by universities or by the corporate world. And as universities and corporations differ, so do the relationships between the laboratories and their managing entities. The laboratories may be single-purpose with a dedicated mission or multi-purpose with diverse responsibilities. Consequently, students were present at a variety of sites under different conditions through the SRP experience. Nevertheless, research indicates little variability in student data for participation at the different locations. The end result for the students was much the same, regardless of site. This suggests that the commonality of participation in the SRP Program sponsored by DOE through OER is sufficient to ensure certain kinds of outcomes. Thus, the SRP Program serves as a representative model for the various kinds of student research programs sponsored by DOE and demonstrates the proven ability of DOE and the participating National Laboratories to implement and carry out successful educational programs. (A summary concerning the SRP programs can be found in Appendix B which consists of program highlights excerpted from the U.S Department of Energy, Student Research Participation Program, Profile and Survey of 1979-1982 Participants.)

Science Semester Programs

Several other undergraduate programs should be mentioned that provide research experiences. Two such Science Semester programs, now in their second decade at ORNL, operate through prestigious consortia of small, liberal arts colleges. A new program, implemented in 1987, and funded through OER, is the Science and Engineering Research Semester (SERS) program. Through the SERS Program, the potential for attracting quality students representing a wide range of academic institutions is dramatically increased, and consequently the pool of potential scientists and mathematicians is enhanced. While these Science Semester programs have different names and different funding sources, they are similar in that the emphasis is on the provision of a quality research experience which will encourage students to pursue advanced degrees in scientific or technological areas. And of course, for the SERS Program, an additional goal is that students will return to a National Laboratory and take part in energy-related research. From the perspective that most participants do in fact pursue graduate degrees in science, engineering, and/or mathematics, these programs are successful. It is too soon to determine if SERS students do choose careers in energy-related research. However, it is known that SRP participants, in many respects analogous to SERS participants, are three times more likely to work in a federal government laboratory as are other U.S. scientists and engineers. This certainly suggests that SERS participants will exhibit similar career choices. (Information concerning educational programs at ORNL can be found in Appendix A which consists of the relevant material excerpted from the Oak Ridge National Laboratory Institutional Plan: FY 1989-1994.)

Precollege Education

Background

There are a great number of studies that document the deficiencies of our educational system in the area of science, engineering, and mathematics and while the numbers may change, the overall picture is the same. This painted picture is not optimistic but rather bleak. A report, Science and Engineering Education, (A complete copy of this report is included in Appendix C) commissioned by former Secretary of Energy, John S. Herrington in 1987, had as its goal a "review of DOE's activities with the education community to ensure that DOE is playing its proper role vis-a-vis other federal agencies and the private sector in the support of scientific and technical education and training." The Energy Research Advisory Board (ERAB), charged by Secretary Herrington to develop this report, does a superior job in summarizing: (1) existing literature concerning the status of science, engineering, and mathematics education; (2) relevant demographic predictions; and (3) the involvement of DOE in support of scientific and technical education and training. This report not only summarizes existing information, but also develops recommendations for DOE. While the scope of the ERAB report is broad, covering university, continuing education, precollege, and public awareness, the balance of this paper will deal only with the areas of precollege education programs and public awareness.

According to the ERAB report, among many others, to ensure a literate public and an adequate supply of scientifically educated and trained personnel, it is necessary to impact the educational system at the precollege level. The efforts of DOE and the National Laboratories have been successful in the area of college and university activities, meeting the goals of encouraging young people to pursue advanced degrees and to work in energy-related careers. However, all indications are that to meet the needs of tomorrow, efforts in science education must begin at a much earlier period. The success of DOE and the National Laboratories in its existing educational programs clearly suggests that the interest, expertise, and commitment is present for equal success in the precollege area. Information exists which defines the national crisis in science, engineering, and mathematics and makes clear that to meet the needs of the future, efforts must be directed at the precollege area. That is not to suggest that efforts at the college and university level be decreased but rather that efforts at the precollege level be expanded, utilizing the demonstrated expertise and resources of the National Laboratories.

Part of the interest in precollege education at the laboratories is linked to the growing concern of the public about the status of education, particularly in regard to education in science, engineering, and mathematics. Almost daily, the public is exposed to another study, another report, purporting to document the inadequacies in our educational system. There is a particular concern in respect to science, engineering, and mathematics education perhaps because these areas are seen as most important to the nation's ability to remain technologically competitive. According to the ERAB report, there is need for concern in respect to the number of students we educate in science, engineering, and mathematics as well as an equal concern in respect to the quality of this education. Many of our students appear to be nearly illiterate in any scientific sense. And a further cause for concern is that of our "best and brightest". Not only do an insufficient number of our "best and brightest" choose technological careers,it is also documented that when compared with the best of other nations, our best do not compare well, at least at the high school level. It appears that not only are we educating our students poorly, we are educating an insufficient number to adequately and effectively supply our future technological needs. To exacerbate the situation, not only are we educating students poorly, we are educating the wrong mix of students. The composition of the work force is anticipated to change dramatically by the start of the next century with the white male becoming a minority in this work force. And yet, particularly in the area of science, engineering, and mathematics, the majority of current personnel are white males. Foreign students, who may or may not remain in this country, receive a disproportionate number of graduate degrees in the technological areas; women and under-represented minorities do not receive a proportionate number of such degrees.

It seems clear that what is needed are programs that: (1) increase the number of students that choose careers in science, engineering, and mathematics; (2) improve the quality of education of those students choosing such careers; and (3) enhance public understanding and appreciation of science, building support for adequate science education and science policy. It also seems apparent that schools need help in achieving these goals. That statement is not intended to be critical. It should suffice to say that our schools carry a heavy burden, often with inadequate resources. It becomes important for government agencies, the corporate world, the professional societies and other interested parties to work cooperatively with schools to ensure a literate population. Through such partnerships, the educational systems will become much stronger.

Programs At Oak Ridge

At Oak Ridge National Laboratory, our educational programs reside for the most part in the Office of University and Educational Programs (UEP) where the majority of funding is provided by OER. Within UEP, there are major areas of responsibility including programs involving universities, minority initiatives, and precollege. Precollege education is a most interesting and exciting area of responsibility. In part, this is because precollege is uncharted territory, encouraging flexibility in assessing the needs and creativity in establishing programs to meet these needs. What are the needs? In one sense, the answer is quite simple. The needs are to (1) ensure a technological workforce which will meet our future needs and (2) prepare a scientifically literate public. To meet the needs in the precollege education area, programs at ORNL identify three target audiences. Those audiences are students, teachers, and the general public.

Ecological and Physical Sciences Study Center: Students, Teachers, General Public

Students peer through microscopes and suddenly a drop of water comes alive; the connection between acid rain, dying trees, and basic chemical concepts is made clear; an appreciation and understanding of our region is developed through geological experiences and studies of adaptations of Tennessee animals; superconductivity as it relates to fundamental ideas concerning the structure of matter is investigated; insects as decomposers expose participants to insects as friend rather than foe; wolves and owls demonstrate the predator-prey relationship; and pinewood derby cars are used to explore basic relationships between distance and force. The Ecological and Physical Sciences Study Center provides half-day, "hands-on" science experiences for area students from Kindergarten through 12th Grade (K-12), teachers, and the general public. The Study Center, funded by UEP, is managed and administered cooperatively by the National Environmental Research Park (NERP) in the Environmental Sciences Division (ESD) and UEP. The Study Center was conceived and implemented in the Spring of 1984 through the efforts of NERP staff. At that time, several study units in the life sciences were developed and used by the 125 participating students and teachers. The Study Center, since its inception in 1984 has grown tremendously, serving over 15,000 students and teachers in the East Tennessee area. To make these figures even more impressive, including adults involved in Study Center public awareness programs and workshops conducted on a national level for teachers and other science educators the total audience served by the Study Center approaches nearly 20,000. During this year's "slow period" (January through April), nearly 3,000 individuals were involved in Study Center activities. And while the number of participants in the Study Center is rapidly expanding, there is nevertheless a waiting list for participation in Study Center activities.

The Study Center seeks to provide quality "hands-on" science experiences for those involved in its programs. To ensure these quality science experiences, Study Center staff is comprised of highly-qualified individuals, experienced teachers skilled in the teaching of science. There is also a link with the science education faculty at UTK which gives added assurance of the validity of the activities. The most important goal of the Study Center is to provide "hands-on" science activities for area school children and teachers. When children and teachers visit the Study Center, they are exposed to the joy and excitement of science with science presented as a dynamic and exciting process rather than as a collection of facts. The Study Center study units are not intended to replace the science of the classroom but rather to expand and enhance the traditional classroom experiences.

The students, teachers, and other groups participating in the Study Center are diverse. They come from outlying rural districts, from the inner city, from public, private and home-taught schools, and from conventional middle-class communities. All kinds of young people utilize the Study Center. The average, the academically gifted, the slow, as well as the disabled, participate in the Study Center. The clientele range from the preschool child who participates through a home school program to the high school student who comes to learn of superconductivity. It is obvious that with such a diverse student population, the teacher population is also diverse. While school groups are the heaviest users of the Study Center, we also serve such special audiences as scouts, science clubs, and the Southeastern Consortium for Minorities in Engineering (SECME), an organization designed to encourage minorities to consider careers in science and engineering.

The Study Center has two sites it calls home. For the many outside activities, home is the historical Freels Bend Cabin, comprising part of the 36,000 acres making up the Oak Ridge Reservation. The second home, established this past winter, makes use of the facility which houses the Graphite Reactor. Constructed in 1943 as part of the wartime Manhattan Project, the Graphite Reactor is the world's oldest nuclear reactor and the first federally owned reactor to be opened to the public on a routine basis. The reactor operated through 1963 and in recognition of the significant contributions made by the facility, the U.S. National Park Service designated the reactor a National

Historic Landmark in 1966, and in 1968, it was formally opened to the public. It is in this public area that the "indoor" study units are carried out. There are some definite problems associated with each site (i.e., lack of electricity, excessive noise). The sites are ideal in one important respect, they are locations where the students are exposed to real science! At Freels Bend, a natural outdoor setting, students have the opportunity to investigate biological phenomena, such as the role of decomposers or water quality, in a natural environment. At the Graphite Reactor Facility, the students (especially the younger ones) are always filled with awe at the appearance of the reactor. This facility gives the student a concrete feeling of what big science is all about. It is difficult to envision a better place to carry out "hands-on" activities on superconductivity. Certainly a major need of the Study Center is a permanent, year-round home. Experience with the Study Center makes clear that close access to "real science" adds an important component for children (and adults) in fostering an understanding and appreciation of science. To have Study Center activities take place distant from the laboratory not only loses the link of science and the laboratory, but also loses the positive public relations component of students and teachers seeing friendly laboratory staff at work.

Not only do students benefit from quality science teaching at the Study Center, teachers also benefit. Teachers are able to observe master teachers in science, receive curriculum materials for use in their own classrooms, and link with the many resources of the laboratory. Special workshops utilizing the Study Center units are conducted for teachers through the Study Center allowing teachers the opportunity to expand their own teaching skills and develop their own knowledge base without the involvement of students.

For the future there are several areas within the Study Center for expansion. First, there is a need for simple growth of the Study Center itself. At this time, there is a waiting list for participation in the Study Center units which is nearly as great as the number of actual participants. Participation in the Study Center is limited by space and teaching staff. The Study Center presently has many of its study units adapted for use by the disabled; plans are being developed to continue to expand in this area. A major tool of the scientist is mathematics and consequently Study Center activities currently include use of mathematical skills and tools; this is another area for further development. Teacher training is also expected to play a more important role in the Study Center with a greater number of programs for teacher-training being developed and coordinated through the Study Center, utilizing the expertise of Study Center staff and its academic links. A specific proposal to the National Science Foundation (NSF) is being developed for a three year teacher-training program to be implemented in the summer of 1990. For ORNL, this calls for training of (K-6) teachers in the area of material sciences. This is part of a joint effort to present a multilaboratory proposal to NSF with the goal that sums of the individual laboratory strengths will be more than the strengths of the individual parts. The Study Center will serve as the coordinating body for the management and administration of the program. Finally, the Study Center intends to become more visible in the area of public awareness, planning more programs for the general public as well as for family involvement. It does seem clear that if the Study Center is to grow in the many dimensions seen as important, expanded space and staff become important.

National Programs for Students At ORNL

The precollege program at ORNL has other programs whose primary focus is students. Two of the programs are part of highly visible national programs. The Department of Energy, through OER, sponsors the High School Science Honors Program. This Program brings to participating laboratories outstanding high school students from across the country and selected foreign countries. Each state and participating foreign country sends one student to ORNL for a two-week research experience in the Environmental Sciences Division (ESD). The theme of the Program at ORNL is that of Environmental Impact; students join staff scientists in ESD in investigating environmental issues grouped around three major areas: global carbon/greenhouse effect, low-level hazardous waste management, and problems stemming from air pollution. Students are housed at Maryville College where they are able to make use of the many recreational opportunities available at the small, liberal arts college. During their stay at the laboratory, students are involved in research activities, lectures, small group seminars, role playing, and of course, social activities. The Program at ORNL is a great success and this is directly related to the commitment and leadership of the staff in ESD. Over 100 staff members were involved in last year's Program, a major factor in the excellent Program carried out at ORNL.

Project SEED is a national program sponsored by the American Chemical Society (ACS). The goal of SEED is to encourage young people who might not normally consider careers in science, engineering, and mathematics to consider careers in those areas. SEED students take part in a ten-week summer program for which they receive a stipend of $1,000 (part of which is supplied by ACS). As part of the SEED program, students are matched with a mentor and take part in on-going research, develop and submit a written report of the research, and participate in career education activities.

Local Program For Students At ORNL: Special Honors

A local program for high school students is the Special Honors Program for High School Students. This program initially provided academic year research experiences for academically gifted high school students. Students join their science mentors in developing a research plan and work together to establish an appropriate approach to the problem. In recent years the program has been expanded to provide such research opportunities during the summer and to facilitate participation by college students. There is no pay for students involved in this program. The students participating in the Special Honors Program have done research in a wide variety of areas including, but not limited to calculating diffusive loss in a rippled tokamak, writing computer programs for simulating and displaying diffusion limited aggregation, the study of ceramics using x-ray techniques, determining the effect of grazing by snails on different growth forms, and mapping of genes arising in transgenic experiments.

Local Program for Teachers and Students: PALS

A new program with dramatic potential is the Partnerships at the Laboratory in Science (PALS). The PALS program began, and is still primarily, a partnership with the science departments of the Oak Ridge Schools. As a result of this official partnership, a speaker/demonstrator program has been developed and an equipment loan program is being implemented. Also, through the Partnership, students in the Oak Ridge schools are involved in an ongoing research effort to characterize the Cedar Barrens located close to Jefferson Junior High School. Teachers now have a formal method to interface with the laboratory. The PALS program provides a mechanism for organizations to interface with laboratory resources and the schools. For example, the precollege program is now involved in the various school "Invention" programs, such as "Invent America" and "Invention Convention." While the Partnership is officially with the Oak Ridge Schools, the PALS program allows the laboratory to respond to requests from other school systems. As other systems learn of the PALS program, they are eager to be involved and do not hesitate to make contact. Such interactions are important opportunities to influence science education in East Tennessee, in rural, urban, and city schools, and is another area in which expansion is important. Through the PALS program, it becomes possible to implement an extensive outreach program.

Programs such as the High School Science Honors Program, Project SEED, Special Honors, and PALS are ones which are heavily dependent on laboratory personnel. For these programs to exist and be successful, staff members must be willing to give of their time. The staff at ORNL is outstanding in their support of precollege initiatives. They excel in their willingness to be involved in precollege science education. Without exception, virtually any reasonable request can be honored because the scientists support precollege programs. This support may range from mentoring a high school student, to speaking in an elementary classroom, to working with the High School Science Honors Program, to developing curriculum, to giving of their Saturdays to talk to teachers. There is no direct pay-back to the staff. With precollege students, the "break-even" point in respect to research contributions is rarely met as it often is met with other research participation programs. There is no mechanism for reward to the staff in any monetary sense and yet, the staff scientists continue to be supportive of precollege education. It is obvious the staff is concerned and caring and wants to contribute. They contribute for a variety of reasons: out of altruism, because they want to return some of what they were given; because they want to help in the educational process; and because they enjoy working with students. There is another reason they contribute and that is a most important one--they want to pass on the joy of science and the excitement of the scientific process. A good question is "why do people study science?" There are many good, possible answers to explain why people study science. Economic strength, technological leadership, the assurance of an adequate defense, are all good reasons to study science. But when a scientist is asked why he or she chose science as a career, the answer is almost always the same. Science is fun! And that is what our staff wants to pass on to young people--the excitement and fun of science.

Teacher Programs At ORNL

The laboratory is actively involved in teacher enhancement programs. Through the Study Center, teachers observe exemplary science teaching and have the opportunity to take part in workshops designed to assist in improving the teaching of "hands-on" activities. In a more structured manner, there are several summer programs at the laboratory which support research appointments for teachers. DOE, through OER, funds the Teacher Research Associate (TRA) Program. Teachers are selected on a national basis for placement at a participating laboratory. Teachers are then matched with a mentor and take place in an eight-week research experience. The teachers receive a stipend of $500/week and a housing allowance for those from out of the area. They also take part in seminars and in curriculum development activities. And, of course, there are social get-togethers! Science Teachers Research for Vital Involvement (STRIVE) is a similar program which is a cooperative venture of Oak Ridge Associated Universities (ORAU) and ORNL. Another summer opportunity for teachers is in connection with the High School Science Honors Program. Teachers are hired to work as counselors for the Program, serving as a liaison between the students and the scientific staff. This provides teachers with the opportunity to work with the "best and brightest" and to participate in research activities in ESD.

Another way the laboratory links to the teaching community is through Partners for Resources in Science and Mathematics (PRISM). PRISM is a regional group of teachers who meet on a regular basis to plan, develop, and organize teacher workshops for area teachers. They have developed a plan for an equipment loan program along with a loan "wish list" for area schools. PRISM also serves as an advisory board to assess precollege programs under consideration by the laboratory.

An excellent example of the kind of linages to be promoted is referred to as the "Jane Whitaker Story." Jane is a science teacher at Lenoir City High School, serving as Chairman of the Science Department, and is an outstanding science teacher. Jane has participated in the High School Science Honors Program and has served as chairman of PRISM. Through her association with ORNL, Jane and staff members at ORNL have developed curriculum materials on superconductivity which she uses at her school. She has also conducted workshops locally and on a national level using the superconductivity materials (the materials have been distributed on a national basis through the Department of Energy as part of their recognition of National Science and Technology Week). Jane utilizes the technical staff to judge science projects, give talks at her school and to serve as mentors to her students. Such linkages have a ripple effect, affecting not only area teachers and students, but also possessing the capability for national impact.

The primary goal of working with teachers is to affect the teaching of science in a positive way. This may be done by introducing the teachers to the world of research, by assisting them in developing curriculum for their students, by facilitating their ability to carry out "hands-on" activities with their students, by acquainting them with skills to enhance their science teaching, and by being a force allowing for revitalization. By teachers working with other teachers, and using the Office of University and Educational Programs as a focal point, an existing support system has been developed and sustained throughout the years. Teachers are encouraged to maintain their links with the laboratory and to develop mentor relationships with the technical staff. Teachers perceive UEP as a resource they can use not only to access the laboratory but also as a link to the educational community and its programs. Through these links with the laboratory, teachers return to use ORNL as a resource and to link their students with the resources of the laboratory.

Programs For The General Public At ORNL

The third target audience for precollege is that of the general public. It is most important to include the general public in our laboratory programs. Not only does such involvement provide an opportunity to expand the general understanding and appreciation of science, it should build support for our overall educational programs. Throughout the year, special programs are made available for the public. These programs have included those on botany, predator awareness, and bird habitats.

While some of these special programs are for adults only, others encourage the participation of families. Our adult programs may often attract scout leaders and others who work in a teaching capacity, thus expanding our educational network. In respect to family science, there is rather clear evidence that working through the family network improves the achievement and attitudes of young people (and their parents) toward science. Consequently, "family science" is also an area of growth.

Special Projects At ORNL

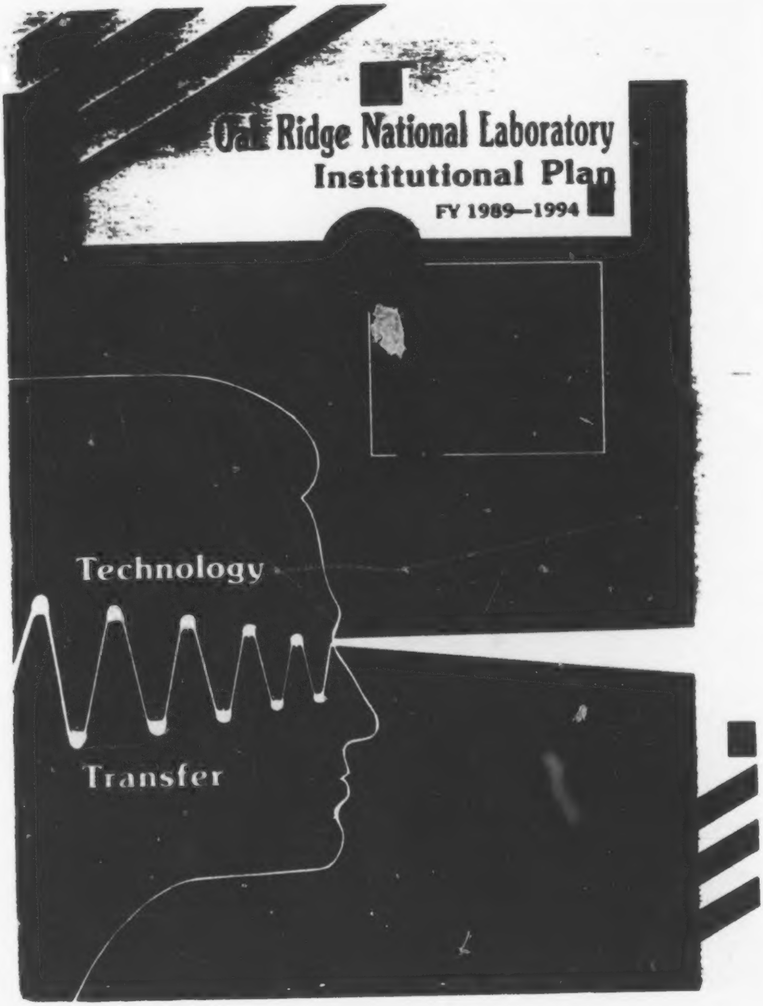
Another growing precollege area is that of special projects. Some of these special projects are very concrete and their effects are visible and immediate. Special programs are held at the laboratory to recognize National Chemistry Week and National Science and Technology Week. A Science Bowl, in cooperation with Pellissippi State Technical Community College, was started this year and plans are to make this an annual event. Involvement in the Junior Science and Humanities Symposium and The Southern Appalachian Science and Engineering Fair, cooperative efforts with the University of Tennessee, will be continued. Many of our special projects are made available through the Study Center. This year, special Study Center programs, one for minorities and one for girls, were held during spring break. Again through the Study Center, there will be special summer science experiences, two one-week programs, offered during the summer for area school children. Summer Study Center activities are also expected to be a major area of growth. (Press clippings describing precollege programs can be found in Appendix D) There are other kinds of special projects whose effects are not immediately apparent and which have as a long-rang goal to assist in ORNL becoming a resource center in precollege science education in this region. Many of the existing programs are components of this long-range goal, but there are additional activities which are necessary. To serve as a regional resource center, it is important to be actively involved in local, state, regional, and national organizations and aware of current educational developments and programs. Through linkages with organizations and groups with common or similar goals, (American Association for the Advancement of Science, American Chemical Society, National Science Teachers Association, and Association of Science and Technology Centers to mention but a few) the strengths of these organizations can be interfaced with the strengths of the laboratory to build a strong regional science resource center in the area of precollege science education.

Conclusions

The farsighted vision of those who initiated and implemented the Atomic Energy Commission, recognizing even in 1946 that education in the sciences and technology is the life blood of the National Laboratories, is to be commended. That DOE has continued to not only support but to expand its educational role, using universities and its National Laboratories, is also most laudatory. The educational activities supported by DOE and its predecessors have had a profound beneficial effect on education. This documented effect has been most marked through the ability of DOE-sponsored programs to encourage students to pursue graduate degrees in science, engineering, and mathematics as well as to pursue energy-related careers. It is clear that the support of educational activities is in the best interest of DOE; for DOE, of necessity, has an intimate dependency not only on a technical staff composed of the very best but also on a literate public willing to provide support for the DOE missions. It is also clear that DOE through its National Laboratories has the resources and expertise to do even more to ensure a quality education for all, particularly in those areas relevant to its mission.

I believe far more could be done, and is appropriate to be done, by DOE in the area of science education, especially in the precollege arena. The vehicle is present, through the DOE National Laboratory family, to have maximum impact on the quality of science education. I would hope that the mission of DOE would expand its educational efforts focused on the precollege population while also working to enhance public literacy. As Director of Oak Ridge National Laboratory and as a concerned citizen, I applaud this Subcommittee and the Congress for their support of efforts by DOE to utilize the National Laboratories as teaching tools. I noticed with pleasure that in Secretary Watkins' prepared remarks for his confirmation hearing, he said, "The laboratories will also have a growing role in helping high schools and universities motivate young people to seek vocations as scientists, mathematicians, and engineers of tomorrow. We are not doing enough in our nation to encourage young people, and particularly the growing number from minority backgrounds, to pursue careers in science and engineering. I appreciate the opportunity to be here today to address this most important area of science, engineering and mathematics education and the National Laboratories. I am committed to the role of the national laboratory as a significant resource to improve science, engineering and mathematics education. I hope to continue to work with Secretary Watkins, members of the Subcommittee, members of Congress, and of course, with you Chairman Lloyd, to attain the goal of quality science, engineering and mathematics education for all. Thank you Madam Chairman. I would be pleased to answer questions.

APPENDIX A



Oak Ridge National Laboratory
Institutional Plan
FY 1989—1994

Technology
Transfer

Designated User Research Facilities

ORNL has served for many years as the steward of numerous, highly sophisticated experimental facilities. These user facilities are designed to jointly serve the technical community and DOE missions by minimizing unnecessary duplication, promoting beneficial scientific interactions, and making the most effective use of costly and, in many cases, unique equipment.

Visiting scientists using these facilities are an important source of external interactions for ORNL. In 1988, more than 400 visiting researchers collaborated with ORNL scientists on projects involving user facilities (Table 43). Traditionally, about one-half of these collaborations involve university scientists (Fig. 34), but stronger ties with industry and relaxed patent regulations have prompted a greater number of industrial participants. Figure 35 shows

Table 43. Experimenters at designated user research facilities[a]
(FY 1988)

	University		Industry		ORNL		Foreign		Total	
En Tandem Van de Graaff	19	(724)	0		14	(491)	6	(46)	39	(1,261)
Holifield Heavy Ion Research Facility (HHIRF)	85	(579)	0		34	(498)	25	(172)	144	(1,249)
Oak Ridge Electron Linear Accelerator (ORELA)	4	(279)	2	(29)	16	(1,669)	2	(13)	24	(1,990)
National Center for Small-Angle Scattering Research (NCSASR)[b]	23	(140)	7	(33)	9	(87)	3	(25)	42	(285)
Neutron Scattering Facility[b]	0		0		0		0		0	
Shared Research Equipment (SHaRE)	31	(217)	3	(31)	28	(650)	2	(34)	64	(932)
Surface Modification and Characterization (SMAC) Laboratory	36	(349)	10	(17)	40	(1,165)	6	(68)	92	(1,599)
Bioprocessing Research Facility	6	(79)	1	(2)	0		2	(95)	9	(176)
Health Physics Research Reactor[b] (HPRR)	0		0		0		0		0	
National Environmental Research Park (NERP)	62	(1,495)	3	(69)	43	(1,341)	1	(1)	109	(2,906)
Roof Research Facility	1	(1,680)	1	(15)	0		0		2	(1,695)
High Temperature Materials Laboratory (HTML)	13	(68)	9	(80)	94	(929)	0		116	(1,077)
Total (12 facilities):	280	(5,610)	36	(276)	278	(6,830)	47	(454)	641	(13,170)

[a] Number of users is provided; number of user-days is in parentheses.
[b] Facility affected by DOE reactor shutdown order.

trends in the number of outside users of our facilities since 1979. The use of user facilities is expected to increase as ORNL seeks greater interaction and collaboration with other research organizations and industries.

A major factor influencing the use of user facilities in FY 1987 and 1988 was a result of DOE's order on March 26, 1987, to shut down all research reactors at ORNL. This order directly affected the following facilities:

- the Health Physics Research Reactor (HPRR),
- the National Center for Small-Angle Scattering Research (NCSASR),

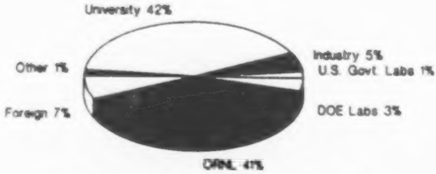


Fig. 34. Participants at ORNL user facilities (FY 1988).

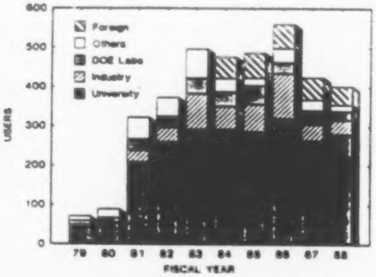


Fig. 35. Number of outside users of ORNL facilities.

- the Neutron Scattering Facility (NSF), and
- the Low-Temperature Neutron Irradiation Facility (LTNIF).

In addition, DOE's decision to place the Bulk Shielding Reactor (BSR) into cold shutdown condition has led to the elimination of the LTNIF, leaving 12 ORNL scientific facilities designated as official user facilities.

User facilities will play a key role in future energy research for the United States; therefore, the associate director of ORNL research reactors and his staff are working to return these reactor facilities to operation as safely and quickly as possible.

University Programs

Educational Programs

Overview of ORNL's University Relations Programs

The DOE University Laboratory Cooperative Program (ULCP), Office of Energy Research (OER), supports research participation and training for students and faculty at ORNL through both ORNL and Oak Ridge Associated Universities (ORAU). Many more participants are supported by programmatic funds housed in the Laboratory's divisions and by other sources, such as colleges and universities, fellowships, and grants. About 1000 university-based researchers are housed annually at ORNL; fewer than 300 are supported by ULCP. In addition, many ORNL divisions have long-standing collaborative research projects with internationally renowned university faculty.

ORNL plays an important role in the education and training of university students through a myriad of programs designed to provide research experience. Over 1000 annual guests at ORNL are affiliated with universities, either as precollege students, undergraduate and graduate students, faculty, or postgraduate appointees. Most visit for short-term research projects, but about one-third are assigned full-time to ORNL divisions for research that may last from 1 to 2 years, producing about 400 person-years of program assistance. They are hosted by the Laboratory through a variety of mechanisms:

- awarding R&D subcontracts;
- encouraging short-term research in the designated DOE User Facilities and other resources;
- supervising students and collaborating with faculty on research participation appointments;
- donating and loaning personnel and equipment resources; and
- establishing close collaborations with specific universities and university consortia.

DOE and ORNL also benefit from university programs. Manpower projections performed for DOE indicate that the demand for well-qualified, trained scientists and engineers will continue to increase, particularly in fields such as health physics and computer science. At the same time, trends point to a decreasing number of science and engineering graduates, especially those who are U.S. citizens. To ensure a supply of personnel to perform energy-related research, DOE has a comprehensive program designed to improve the quality of science education and to increase the number of students electing to study science. ORNL plays an integral role in this program to enhance the research capabilities of educational institutions and to train students for careers in research.

Working with universities is a cost-effective way to achieve ORNL's programmatic goals. ORNL awards numerous R&D subcontracts to universities that sponsor research on campus in support of the Laboratory's missions. In addition, a number of programs are coordinated through the Office of University Relations whereby students and faculty participate in research at the Laboratory. These arrangements are attractive to the Laboratory because they usually cost less than it would to hire additional staff and still maintain quality work.

In addition to being cost effective, university personnel make substantial contributions to ORNL's missions. Recently, for example, important contributions were made by a former postdoctoral appointee and current postdoctoral appointees in the design, construction, and operation of the scanning-tunneling microscope in the Health and Safety Research Division (HASRD). Over the two decades that ORNL has hosted undergraduate students on academic-year science semester programs, students have made substantive contributions to ORNL projects that later were patented and/or received I•R 100 awards. Furthermore, working with university personnel fulfills the Laboratory's technology transfer objectives.

Over 20 different programs provide opportunities for students and faculty to participate in research at ORNL for appointment periods ranging from 6 weeks to several years. About half the programs are administered through ORAU. Opportunities exist for summer and/or academic year appointments. Comprehensive programs for graduate students include graduate internships, summer appointments, and thesis research.

Many university personnel receive training or perform experiments on ORNL's state-of-the-art resources while they are under research-participation appointments. DOE supports a variety of university programs at ORNL, both through ULCP and programmatic funds.

About 105 co-op students were employed by ORNL in FY 1988; by contrast, about 200 students, 48 postgraduates, and 30 faculty received research-participation appointments through programs run by the Office of University Relations. These appointments exclude the almost 200 who received research travel contracts for short-term research visits.

Programs are available through ORAU that help support travel costs for university faculty and graduate students under research travel contracts. Additional programs support travel costs for historically black colleges and universities (HBCU) researchers, such as Minority Institution Research Travel (MIRT) and Very Important Small Institution Travel Support (VISITS). The supported visits may be to perform experiments at user facilities and resources or may be used for consultations with ORNL staff about common research interests.

University Consortia

ORNL has a close relationship with several university consortia. For example, ORNL has had a long-standing collaboration with ORAU on educational programs that has been strengthened through the implementation of several new joint programs as well as joint university outreach activities. In FY 1986, ORNL moved closer to the Southeastern Universities Research Association (SURA), which is another consortium of major universities in the Southeast, through such activities as membership on the Board of Trustees and various committees. ORNL also continues to have strong semester programs with the Great Lakes Colleges Association/Associated Colleges of the Midwest (GLCA/ACM) and Southern College University Union (SCUU) consortia, now both in their second decades.

Research and Development Subcontracts

ORNL awards about 270 R&D subcontracts to over 100 universities annually. These subcontracts generally sponsor research on campus, but may also include provisions for student internships or faculty appointments to perform research at the Laboratory. About 40% of ORNL's subcontract obligations are with UTK (including the cost for the joint appointments under the Distinguished Scientist Program)

In FY 1988, universities in a majority of states, Puerto Rico, and Canada received research funding from ORNL. Money committed through subcontracts to minority education institutions has increased by over 25% during the second half of FY 1988. Program HA is the largest sponsor of university subcontracts, accounting for about 18% in FY 1986. Other major sponsors of university research are Program EB (16%), Program EE (13%), and Program AA (10%). A large percentage (over 45%) of the university subcontracts are sponsored by Work-for-Others agencies.

Research Collaborations

Many long-standing, close collaborations exist between ORNL and individual universities that are based on mutual research interests. About one-third of ORNL's annual R&D subcontract expenditures goes to support collaborative research at 20 prestigious colleges and universities such as the Massachusetts Institute of Technology, the University of Illinois, and the University of California at Berkeley. Most of these collaborations involve outstanding departments at these premier research institutions and include active exchanges of students and faculty.

ORNL is also engaged in a team R&D effort for the deployment of an advanced robotic system capable of performing tasks hazardous to humans and/or whose execution times can be reduced if performed by automated systems. The goal of this project is to develop a generation of advanced robotic systems capable of performing surveillance, maintenance, and repair tasks in nuclear facilities and other hazardous environments. This goal will be achieved through a collaboration among ORNL; the universities of Florida, Michigan, Tennessee, and Texas; and a number of industrial partners. This program is designed to take full advantage of existing resources at all participating institutions. ORNL participates in the research, coordinates the overall effort, and conducts coordinated experiments and integrated equipment tests to demonstrate the overall progress of the team.

ORNL plays a role in enhancing education and research facilities on campus. For example, as part of subcontract agreements, equipment necessary to carry out the research may be purchased. In the past, all equipment had to be returned unless the equipment was too costly to transport. However, recent changes in DOE policy have allowed equipment purchased under subcontract for less than $5000 to remain the property of the school upon termination of the work.

ORNL also participates in the DOE Excess Research Laboratory Equipment (ERLE) program that allows colleges and universities to obtain excess equipment for the cost of transportation only. The equipment ranges from small detectors to sophisticated analytical instruments and may be new, used, or in need of repair. The Laboratory maintains a data base, which is updated monthly, that lists available equipment. University personnel can access this data base.

Besides providing equipment resources, ORNL works with academic institutions to enhance their educational programs and research capabilities by donating personnel and resources. ORNL staff members frequently give seminars at universities throughout the nation, either because of an ad hoc invitation from faculty or through formal programs such as the ORAU Traveling Lecture Program and the Industrial Research Institute (IRI) Visiting Scientists Program. These visits, typically lasting a day, allow students and faculty to consult extensively with the scientist and give university personnel insights into some of the cutting-edge science performed at the Laboratory. About 75 to 100 of these visits are made annually.

Many ORNL staff members are affiliated with universities on an adjunct basis to teach classes and to collaborate with faculty on research projects. Some 25 to 30 adjunct professors from ORNL receive compensation under official appointments from The University of Tennessee. Many others donate their teaching talents to other institutions, such as Knoxville College, Tennessee Technological University, and Roane State Community College.

ORNL staff also teach short courses as part of ORAU's manpower training programs sponsored by DOE. ORNL also provides other types of assistance to faculty, including critical review of proposals and manuscripts and organizing joint meetings and conferences.

Facilities and Equipment at ORNL

ORNL is the home of 12 official DOE user facilities. These facilities offer unique opportunities for outside researchers to perform experiments on state-of-the-art equipment at minimal cost. Many of these facilities are supported by separate operational funds, and users need pay only their travel and housing costs. Of the non-ORNL participants using these facilities over the last 5 years, about 60% came from universities.

In FY 1988, nearly 300 university researchers performed experiments for 5610 user days in ORNL's DOE user facilities. The largest percentage of the university-based users (31%) perform research at the Holifield Heavy Ion Research Facility. Other facilities heavily used by university researchers include the Oak Ridge National Environmental Research Park and the Surface Modification and Characterization Collaborative Research Center (SMAC/CRC).

Other unique resources that may be available to university researchers include supercomputing capability (a Cray X-MP and two 64-node parallel processors), advanced electron microscopes, analytical equipment (including a new Fourier transform mass spectrometer), and other research tools. In addition, the Walker Branch watershed, located on the Oak Ridge Reservation (ORR), is one of the best sites in the world for watershed research. Arrangements to use these resources are made directly with research staff or through the Office of University Relations.

Precollege Programs

Much of ORNL's interest in precollege programs is in response to the federal government's renewed interest in science and mathematics education. The quantity and quality of science and mathematics training at both the college and precollege levels is declining. Some of the problems have been manifested in the university in terms of poor precollege preparation and declining enrollment, especially of U.S. citizens and minorities. Within the last several years, DOE has also recognized that this problem may affect our nation's ability to compete in international research arenas in the future. Therefore, DOE has implemented several precollege programs designed for both students and teachers. ORNL has also responded to the calls for action with several new precollege activities, organized and managed by University Relations. University Relations works closely with Public Relations staff.

ORNL hosts high school teachers during the summer and high school students year-round. In addition to research participation, other events are organized for summer guests to the Laboratory, including a seminar series that focuses on major Laboratory programs and a series of tours so that attendees can learn of the variety of research that takes place at ORNL.

For many years several programs have existed to avail the Laboratory to high school students and teachers. In the summer of 1985, 14 high school teachers were participants in the pilot Summer Field Experience program that allowed them to assist ORNL researchers for 6 weeks.

Two new summer research programs, the Carbon Dioxide program and the High School Honors Workshop, were implemented during FY 1988. The Carbon Dioxide program is a national program involving teachers concerned with research about the global carbon cycle and with linking this research to curriculum development. Teachers were also involved as science associates with the High School Honors Workshop, serving as liaisons between the students and ORNL science staff.

In FY 1988, 28 teachers participated in research activities at ORNL under the management of the University Relations Office. A teacher advisory group, Partners for Resources in Science and Mathematics (PRISM), has been working with area teachers in providing workshops and equipment loan programs. The workshops seek to link the "big science" of the Laboratory with the existing science curriculums. The equipment loan program attempts to provide teachers with needed equipment. Another teacher-oriented initiative in FY 1988, PRISM Associate Teachers (PAT), encourages teachers to link with laboratory personnel to enhance their own knowledge in a given area and to develop materials appropriate for their teaching assignment. For example, one teacher has worked with staff in ORNL's Solid State Division to develop materials linking superconductivity to traditional science topics.

Programs established for high school students have been expanded and new programs have been implemented. ORNL hosted one of the DOE National High School Honors Workshops in FY 1988, with a focus on environmental sciences. Over 100 Environmental Sciences Division (ESD) staff members provided the workshop with research experience and student lectures and served in other capacities. Fifty-seven high school students, representing all states, the District of Columbia, Puerto Rico, Italy, Canada, Germany, France, and Japan spent 2 weeks at the Laboratory.

During their stay at the Laboratory, these students were involved in environmental studies dealing with the effects of contaminants on the environment. The Special Honors Study program implemented in FY 1986 allows exceptional high school students to conduct a study project in an area in which they have a special interest at the Laboratory under the supervision of an ORNL staff member. Seven students participated in the program in FY 1988, for a total of 12 participants since the inception of the program.

Initiatives are also being developed to involve minorities in precollege programs in an effort to increase the pool of minority citizens who elect to pursue careers in science and engineering. An example of such a program is the Summer Educational Experience for the Disadvantaged (SEED), a program to encourage economically disadvantaged high school students to consider careers in science and mathematics. This program was initiated in the summer of FY 1988 with a student being placed in the Chemical Technology Division. It is expected to reach a participation level of five in FY 1989. In addition, the "Challenge" program, designed to encourage and prepare minorities for careers in science and related fields, involved staff from the Office of University Relations in FY 1988.

As part of this increased focus on precollege activities, ORNL continues to expand the Ecological and Physical Sciences Study Center (the Study Center), which is one of the most visible and successful precollege programs. The Study Center was formerly the Ecological Study Center (ESC) of the Oak Ridge National Environmental Research Park. Developed by a team of educators, ESC began in 1983 with four study units, functioning during the spring and winter. The Study Center now includes 18 study modules that provide students with the opportunity for hands-on learning in both the life sciences and physical sciences. The units are offered generally as half-day field activities and are tailored for the academic level of elementary, junior high, or senior high school students. The Study Center now operates year-round, including Summer Science Saturdays for adult community members and children. Since its inception in 1983, the Study Center has hosted over 8000 participants.

Demand for the program continues to be strong; many more requests are received than can be accommodated. Several of the study units have been adapted for use with "handicapable" students in the standard Study Center format. In addition, several of the study units have been modified for indoor programs and are also presented for "handicapable" individuals.

A partnership with the Oak Ridge schools has been developed and implementation has begun to link the science departments of the schools with the resources of the Laboratory. The Laboratory possesses unique skills and a knowledge base that can serve to assist the schools in enhancing the scientific educational experiences of both students and teachers. This partnership will serve as a model of how communities and laboratories can benefit from such partnerships.

Undergraduate Programs

Several undergraduate student programs are worth mentioning in more detail because of their popularity, uniqueness, or newness. The Technology Internship Program (TIP) provides training opportunities for students pursuing an associate degree. Although the program is only 4 years old, most of the participants have already been hired for regular employment as technicians. The Student Research Participation program brings in students during the summer between their junior and senior years for 10-week appointments. Many of these students are subsequently hired for summers during graduate school under the ORNL Summer Research Internship program.

The Oak Ridge Science Semester program, almost two decades old, is an academic-year research participation program. Selected upperclass students who attend colleges belonging to GLCA/ACM and SCUU spend one semester at ORNL performing research and taking courses taught by resident faculty from the consortia, for which they receive academic credit. A 10-year survey of the GLCA/ACM program indicated that over 90% of the participants had received a

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graduate degree or were currently enrolled in graduate school.

The Special Summer Program provides opportunities for undergraduate students from HBCUs to participate in research as early as the freshman year, with the intention to rehire for subsequent summers through graduation. Because of this program, and other university-relations programs, the number of participants from minority educational institutions has increased significantly over the last two fiscal years. The number of students and faculty from HBCUs has climbed from 4 in FY 1985 to 29 in FY 1988, and the number of students and faculty from Hispanic institutions was increased from none in FY 1985 to 19 in FY 1988.

Graduate Programs

Graduate students can perform prethesis research through several programs. ORNL has hosted a number of students for summer practicum experience who have been awarded DOE fellowships. Thesis research, which can be sponsored by ORNL R&D subcontracts, is also the objective of the Laboratory Graduate Participation (LGP) program. Students selected for this program perform full-time thesis or dissertation research for up to 2 years under the direction of his or her graduate committee, which would include both ORNL and university representatives. This program is very competitive and selective; typically fewer than ten appointments are made annually.

All candidates must be approved by the ORNL Graduate Fellow Selection Panel, a committee composed of professional staff representing all ORNL research and technical divisions. The ORNL Graduate Fellow Selection Panel also is responsible for approving students with masters degrees and postdoctoral applicants who are appointed through the Postgraduate Research Training/Appointment programs. Also highly competitive and selective, this program allows ORNL staff the opportunity to receive valuable program assistance from recent graduates desiring further research experience. Special attention is paid to specific programmatic needs. Laboratory employees have been recruited from graduate student programs. For example, the Summer Research Internship program is designed for graduate students with a minimum grade-point average of 3.5. Students enrolled in health physics graduate programs were actively recruited; four were hired as interns for summer 1986. In addition to the health physics interns, graduate students have also been recruited specifically to assist with activities in the national Hazardous Waste Remedial Actions Program (HAZWRAP).

The University of Tennessee, Knoxville

UTK enjoys especially close ties to the Laboratory. Many UTK faculty members have served as consultants and research participants at ORNL. ORNL staff have served on UTK advisory committees, and UTK staff have played a similar advisory role at ORNL. Many ORNL staff have taken advantage of the UTK Resident Graduate Program in Oak Ridge, which offers evening courses to those pursuing advanced degrees in a variety of scientific and engineering disciplines.

Science Alliance

A current memorandum of understanding (MOU) in effect is with UTK, which was initiated as part of the Science Alliance. Sponsored by the state of Tennessee, this Center of Excellence at UTK operates under the auspices of the Better Schools Program.

The purpose of the Science Alliance is to encourage joint research collaborations between ORNL and UTK, thus fostering a unique environment for research training. Many different activities fall under the program's umbrella, but the one most visible is the Distinguished Scientist

Program, whose purpose is to strengthen R&D in the region by attracting scientists and engineers of high national and international stature. The selected scientists hold a tenured position as full professors at UTK and appointments as senior research scientists at the Laboratory. ORNL and UTK share the costs of these appointments equally. Three Distinguished Scientists began appointments in FY 1988. Several have already made substantial impacts on both UTK and ORNL through the number of personnel and contract awards that they have accumulated since the start of their appointments.

Other activities sponsored by the Science Alliance include a summer research program at ORNL for undergraduates and the development of joint graduate programs. These joint programs include a new Master of Science program in biotechnology and a graduate program in measurement and control engineering.

The UTK Graduate Programs at ORNL

Perhaps the least known, yet strongest ORNL-UTK joint programs are the two UTK graduate schools located at ORNL. The Oak Ridge Graduate School of Biomedical Sciences (ORGSBS) and the Graduate Program in Ecology are both in their second decade. Both graduate programs at ORNL provide a home for several UTK faculty.

Housed in the Biology Division at ORNL, ORGSBS offers full-time graduate study for M.S. and Ph.D. degrees and for postdoctoral training. Student support is provided by UTK through research assistantships and federal grants. Most of the school's teaching and research training is provided by Biology Division staff. The current enrollment is around 40 graduate students and postdoctorate appointees.

The second UTK graduate program at ORNL is the Graduate Program in Ecology within ESD. Similar to ORGSBS, the Ecology program offers full-time graduate study for M.S., Ph.D., and postdoctoral students. The students are largely supported by ESD programmatic funding. About 20% of the research training is provided by ESD staff, who also teach courses under adjunct appointments. Enrollment is typically about 15 graduate and postgraduate students.

Minority Institutions

On January 19, 1988, ORNL and DOE signed an MOU with Southern University. The MOU was initiated to formalize joint program activities that will assist Southern University in enhancing its research and educational capabilities and assist DOE in achieving its missions. Subcontracts are in process in the amount of $245,000, which includes two subcontracts with the Y-12 Plant.

On September 23, 1988, ORNL and DOE also signed an MOU with the University of Puerto Rico (UPR). A Field Work Proposal was submitted requesting funding for various collaborative ventures for a period of 3 years to augment existing initiatives involving UPR students and faculty in environmental science research.

FY 1988 was a year of significant expansion for the program. Over 30 students and faculty members spent summer internships at ORNL and the Y-12 Plant. Subcontract commitments increased nearly 40% from FY 1987 commitments, even as total commitments in subcontract awards to higher educational institutions (HEIs) decreased by over 15%. FY 1988 subcontract commitments to minority educational institutions (MEIs) was $1.4 million. This represented 8.2% of the total subcontract commitments to HEIs being received by MEIs.

Efforts continue to identify excess equipment that might be used on MEI campuses toward enhancing their research capabilities. During FY 1988, through various interactions with MEI faculty, over $112 thousand worth of equipment was loaned to four MEIs. Also during FY 1988, efforts were made to establish new Field Work Proposals (FWPs) to provide continuity of funding of subcontracts beyond one year with selected MEIs; toward this end, 11 FWPs were established with projected award commitments of over $3.3 million through FY 1991.

In April 1987, Energy Systems appointed an MEI Program Manager under the direction of the Energy Systems Director of Minority Program Development to act as the focal point for Energy Systems involvement with HBCUs. Because most of the MEI/Energy Systems interactions take place with ORNL, the MEI Program Office is located in the ORNL Office of University Relations.

The main thrust of the program is to develop opportunities through internal (Energy Systems) and external (MEI) interactions. Internally, the program emphasizes communication of Energy Systems MEI program objectives; externally, attempts are made to encourage MEI participation in research through workshops, established contact networks, mutual visitations, and professional assistance.

Program activities and initiatives are also under way with other minority educational institutions including UPR, New Mexico Highlands University, and the Ana G. Méndez Educational Foundation (AGMEF). Energy Systems is also working with ORAU, the Southeastern Consortium for Minorities in Engineering (SECME), and various precollege school systems seeking to increase the number of minorities and women who elect science and engineering programs in college.

Several new initiatives in support of precollege and minority programs are expected to be funded by the KE program next year. These new initiatives include the following.

- With Oak Ridge serving as the lead laboratory in partnership with seven other participating DOE laboratories, a National Science Foundation (NSF) grant proposal for a multilaboratory teacher training program for teachers in grades K–8 has been submitted.
- Several national teacher training programs are expected to be expanded and/or modified in FY 1989. The newly initiated Carbon Dioxide program, with emphasis on curriculum development in the area of carbon dioxide, is expected to expand to a level of 15 participants; the reorganized national high school teacher enrichment program, formerly known as REST, is expected to involve another 15–20 teachers doing research during the summer of 1989.
- MOUs with UPR and with the Science and Technology Alliance were signed in 1988, with resulting plans to expand collaborations with the represented institutions through increased student and faculty research participation as well as through the support of faculty and ORNL staff visitations. Precollege programs and joint research projects are included in the collaborative efforts leading from the MOUs. Other precollege areas to be further developed concern programs that address specific manpower needs to DOE.
- Programs are being developed that involve efforts to provide activities for females and other under-represented minorities, to enhance mathematics education, to strengthen precollege education in the physical sciences, and to provide academic-year activities to revitalize teachers and students.

Proposed Programs

In its efforts to increase interactions with premier academic institutions, ORNL has established an MOU with Duke University. ORNL is also expanding its interactions with the service academies through the Service Academy Research Associates (SARA) program. Increasing numbers of students from the Naval Academy, West Point, and, for the first time, students from the Air Force Academy will participate in the

SARA program. Faculty from the service academies will also be encouraged to participate.

The number of university research participants is expected to increase in FY 1989 with the continuation of the Oak Ridge Science and Engineering Research Semesters. When fully operational, the Oak Ridge Science and Engineering Research Semester program would support over 300 students annually for research participation and training, mostly during the academic year. All participants will be housed in a multipurpose building to be constructed in central Oak Ridge. The program is being successfully phased in with over 60 participants in FY 1988.

Summary

The precollege and university relations programs will continue to grow significantly in the future. It is important that a facility be developed that meets the needs of our growing precollege and university programs. ORNL will continue to involve new groups in our activities, implement new programs to meet needs, and otherwise enhance our education and training activities. The catalog of programs currently offered by ORNL is considerable and impressive, but opportunities for new initiatives still exist.

The ORNL University Relations program will continue to grow and act as a model for other federal laboratories and corporate entities in their efforts to enhance the education of the nation's youth. ORNL has demonstrated a commitment to increase the involvement of university personnel in its R&D activities. It is imperative to supply well-trained, qualified technical personnel for the future. The Laboratory is assisting DOE in achieving this goal in two ways: (1) by providing opportunities for students of all ages to receive training and to perform research and (2) by encouraging students to attend graduate school in energy-related disciplines. The university interactions are also important in transferring science and technology through sponsoring faculty research participation and visits at ORNL and through ORNL staff visits and lectures on campus. Collaborative research programs with university personnel will continue to be a cost-effective method to receive quality assistance in fulfillment of the Laboratory's missions.

A proposal has been submitted to the NSF for a teacher-enhancement program for teachers from kindergarten through grade 8. This multilaboratory proposal involves eight DOE laboratories, with ORNL serving as the lead laboratory. The proposal calls for a budget of nearly $6 million over a 5-year period and is expected to serve over 400 teachers. The teacher program will focus on "hands-on" activities that link the "big science" of the laboratory to conventional science curricula.

Minority Business Procurement

Energy System's Award Fee Contract with DOE requires that we provide maximum practical opportunity for minority businesses to sell us the commodities and services used in the operation of our facilities and programs.

ORNL management and staff work closely with the Socioeconomic Programs Office and Purchasing staffs to identify and qualify companies owned by socially and economically disadvantaged individuals to participate in the company's purchasing activities. The following activities support this program.

- Outreach—more than 25 trade shows, business opportunity fairs, and conferences for small and disadvantaged businesses are attended each year. Staff members also meet one-on-one with minority companies to enable them to "market" their goods and services.
- Seminars and workshops are cosponsored with DOE and other organizations to help company representatives better understand our

requirements and the correct procedures for doing business with us.

- Large, complex procurements are broken down into smaller pieces to enable greater participation from minority firms.
- Special arrangements are made with Accounts Payable to ensure that prompt payment is made to minority firms to help alleviate cash-flow problems.
- An annual awards program is conducted that recognizes a minority-owned firm and minority colleges or universities for outstanding performance of work for us.
- As part of the awards activity discussed previously, internal staff are recognized for their support of the program by serving as "advocates" for small and disadvantaged companies.
- Strong support is provided to DOE in identifying work that can be awarded to minority companies that have been certified under the Small Business Administration's 8(a) Program. Once the award is placed by DOE, our staff members serve as technical monitors for the contracts.

Placement of contracts and orders with minority companies has increased steadily over the years. Energy Systems has received the following awards recognizing performance in this area.

- FY 1988—Distinguished Prime Contractor of the Year for Region IV—awarded by SBA-Headquarters;
- FY 1988—Small Minority Business Advocate of the Year for the state of Tennessee, Ruby Miller—awarded by SBA-Region IV;
- FY 1988—Corporation of the Year, Portsmouth Gaseous Diffusion Plant—awarded by Columbus (Ohio) Regional Minority Suppliers' Development Council; and
- FY 1987—Small and Minority Business Advocate award, Allyn Zerby of C& TD at ORNL.

APPENDIX B

APPENDIX B

U. S. Department of Energy
Student Research Participation Program

Profile and Survey
of 1979-1982 Participants

Frank M. Vivio
Argonne National Laboratory

Wayne Stevenson
Oak Ridge Associated Universities

Summary of Findings

Since its formation in 1977, the U. S. Department of Energy (DOE) has had the responsibility and legislative authority to develop programs that help ensure adequate supplies of technical personnel for its future research mission. One mechanism for doing this is to provide undergraduate science and engineering majors with DOE laboratory research experience. The DOE Student Research Participation (SRP) Program, sponsored by DOE's Office of University and Industry Programs, is the principal vehicle for arranging and supporting these research appointments.

This report reviews information provided by a sample of the 2,752 SRP Program participants who held appointments from 1979 to 1982. Some of the most significant findings of the study are:

- In 1987, many survey respondents were still working on graduate degrees. However, 42 percent had or expected to receive Ph.D.'s; 22 percent either had or planned degrees in medicine, law, or other professions; and 29 percent expected a master's degree to be their highest degree.
- Over 58 percent have already attained an advanced degree.
- Fifty-four percent of the respondents said that their primary work activity was research as compared to 33 percent of all employed scientists and engineers in the U. S.
- Former SRPs are more than three times as likely to work in a federal government laboratory (9%) as other U. S. scientists and engineers (2.4%).
- Sixty percent of all respondents and 76 percent of those who had completed Ph.D.'s indicated that the program influenced their decision to attend graduate school.
- Females were more likely than males to indicate that participation in the program had an influence on their decision to attend graduate school.
- More than half of the respondents (57 percent) indicated that the program influenced their choice of area of specialization.

In general, the information provided by past SRP Program participants indicates that participation in the program encouraged a majority of them to attain higher levels of education. They indicated that they received valuable experiences that influenced their career development.

APPENDIX C

APPENDIX D

PIE links students

EDITOR'S NOTE: Pat DeRose directs school community relations in the Partners-In-Education program of Oak Ridge Schools. Dr. Linda Cain works with university relations for the Oak Ridge National Laboratory, coordinating education programs with ORNL.

by Pat DeRose and Linda Cain
For The Oak Ridger

Partners-In-Education (PIE)links a local business, agency or organization with Oak Ridge schools so that resources may be shared for mutual benefit.

A partnership is a people-to-people program designed to benefit the business through the enrichment of the school's instructional activities.

Both partners are a vital contributor to the growth of the students in the community and thus the development of a great resource.

The partnership between Oak Ridge National Laboratory and the Oak Ridge school system's science departments is an example of one partnership in action.

This program began in 1988 when a kick off celebration was held and scroll signed by both School Superintendent Dr. Robert Smallridge and Dr. Alex Zucker (with ORNL) indicating their support of the Partners in Education Program.

After the program's initiation, a meeting was held between the Partnership coordinator (Dr. Linda Cain) and Oak Ridge science teachers. While many teachers and students have toured the laboratory facilities, a need was felt to acquaint teachers with the educational programs offered through the Office of University and Educational Programs. To meet this objective, an overview of existing laboratory programs was given at the meeting and teachers were asked to comment on what kinds of services would be helpful.

Responses showed that a speaker/demonstrator program would benefit and topics were suggested. In response, such a program with more than 18 topics has been initiated. They include acid rain, the greenhouse effect, lasers, meterology, robotics and the history of transportation. An equipment/chemical loan program was another area of interest as was assistance in equipment repair.

Since that meeting, an equipment/chemical loan program has been developed which will make chemicals and equipment available on a limited basis. Also, contact has been made to supply technical assistance for equipment repair. Curricular materials are also available on loan.

There are several programs at ORNL which have been enhanced through the Partnership.

The Special Honors Program is one which provides research opportunities for outstanding high school students by pairing students with mentors in their areas of scientific interest. There are four students in various stages f this program.

In the fusion energy division, student Marc Schaub is under the mentorships of Dr. Jim Rome and Dr. Ker-Chung Shaing Dean Huff, under the mentorship of Dr. Vasili Alexiades, is located in the area of applied mathematics. Two other students, Avi Mazumdar and Irene Pedraza, are considering mentorship in the areas of superconductivity (Dr. Doug Mashburn) and applied math (Ray Flanery).

The Ecological and Physical Sciences Study Center is another program at ORNL enhanced through the Partnership. Started in 1984 under the auspices of National Environmental Research Park (NERP) through the leadership of Pat Parr (manager of NERP) and Kathy Blair, the study center director, the program has grown to where in 1988 nearly 7,000 students and adults were involved.

The program is sponsored and manged jointly by NERP and the Office of University and Educational Programs. The center now provides more than 22 half-day activity-based science units to students, teachers and community members in East Tennessee.

Another project involves the Cedar Barrens. Under the direction of Maureen Cunningham of the Environmental Sciences Division, research and study of the Cedar Barrens in the Jefferson Junior High School area as been undertaken. The project involves student efforts to determine the Barrens' characteristics. Currently the area is being divided into plots where soil samples are being taken and analyzed by students.

BEST COPY AVAILABLE

Area elementary students learn at science center

by Jennifer Andoo
Oak Ridger staff

How many of you have ever taken a worm apart?

The question drew oohs and ahs from about 120 students from Brickey, Halls and Kingston elementary schools and Nature's Way Montessori School who gathered at Freels Bend Cabin in Oak Ridge Monday afternoon.

"What do you think about worms?" Oak Ridge National Laboratory Director Alvin W. Trivelpiece continued as the students grinned and marveled at the thought of dissecting a worm.

Trivelpiece was one of four speakers at the fifth anniversary celebration of ORNL's Ecological and Physical Sciences Study Center. The event also marked the first day of National Science and Technology Week.

More than 15,000 East Tennessee area students and adults have used the study center for hands-on experience in environmental science, according to ORNL.

Encouraging the students in their efforts to puzzle over scientific problems, Trivelpiece asked, "How would you find out how many bowling balls are in a stack of hay without touching the haystack?"

"You could burn (the haystack)," a student suggested. "Radar," another chimed in. The students were gathered in a semicircle around Trivelpiece in the muggy outdoor air as a slight breeze blew off Melton Hill Reservoir.

"Don't give up being curious. Always ask why," the laboratory director said.

Joe Lenhard, the Department of Energy's assistant manager for energy research and development, in a brief presentation, reassured the students that all the scientific puzzles won't already have been solved by the time they graduate from college, and emphasized the importance of science to the community and the world.

"Scientists are doing interesting things that are going to affect the way you live. I encourage you all to think about science as a career. It's a fun thing to do," he said.

ORNL and DOE officials have developed many programs to expose students to science at an early age to avoid a potential shortage of scientists and engineers.

"The nation is facing a crisis. We need more scientists and engineers. To really get young people into science and engineering, we know we have to start very early," Chet Richmond, ORNL associate director for environmental and biological sciences, said.

"I hope all of you ... will keep in mind the excitement of science," he said.

Trivelpiece later presented awards to Jill Turner, a Brickey student, and to Steve Sims, a student at Halls, for receiving the grand prize in a "Science Is ..." poster contest. Nancy Hullander, a teacher who advised both students, was also given an award.

Additional awards were given to the following for supporting ORNL's ecological and physical sciences study center:

Ed Aebischer, ORNL spokesman; Marilyn McLaughlin, ORNL spokesman; Vivian Baylor, former director of ORNL's university and educational programs; Dr. Marcella Cranford, Kris Light, Bob Kernohan, and Diane Willis, all ORNL consultants and teachers at the study center; Dave Reichle, director of ORNL's environmental sciences division; Jon Veigel, president of Oak Ridge Associated Universities; Karen Atchley, DOE research and waste management division; Bob Dreyer, Martin Marietta Energy Systems disability programs coordinator; Pat Parr, manager of Oak Ridge National Environmental Research Park; and Cathleen Blair, director of the ecological studies center.

Students, teachers join in barrens study

by Donna Smith
Oak Ridger staff

Oak Ridge National Laboratory workers and city students and teachers joined forces Wednesday afternoon to begin preparations for an intensive study of the cedar barrens area that adjoins Jefferson Junior High.

It wasn't the first time they've worked together. Earlier this year ORNL adopted the city school system through the Partners-in-Education program.

Science teachers will continue their practice of using the barrens for class study, but the study may be more fulfilling for students because they not only earn a grade but help ORNL study the barrens and record information.

"This is not just a school exercise," Maureen Cunningham, a University of Tennessee botanist working at ORNL, said. "The state is very interested in this area and how the commercial area (next to the barrens) affects the barrens."

The cedar barrens is a registered state natural area. Noted for its environmental qualities, the barren's rugged terrain is characterized by limestone outcroppings and shale-dominated soil. It is one of only two sites in the state that has prairie goldenrod. Other uncommon plants like prairie grass are also found on the six-acre barrens.

With machinery on the Crown American site whining in the background, the group began making a grid of the barrens, dividing the area into 10-meter squares.

In the group were Oak Ridge High science teacher Fred Holtzclaw and ORHS students Amy Compton and Mindy Sarafi, Jefferson Junior High science teacher Pat DeRoss, Linda Cain, pre-college science administrator in ORNL's office of university relations, Ms. Cunningham, and Mike Huston of ORNL's environmental sciences division.

Holtzclaw and Ms. Cunningham explained that by graphing the area, students and ORNL staff will be better able to study the area. Ms. Cunningham said using the grid, observers will identify plants and mark which areas the plants are located in, which areas are open spaces, and how plants from one area are encroaching upon other areas.

They will also be able to record what happens to the plants after development starts on the former mall site. All information will be stored for use by future students and probably be published later, Ms. Cunningham said.

While marking the squares with orange flags and stakes, the group noticed fresh deer tracks. Ms. Cunningham said students would also be observing which mammals are in the barrens.

Upcoming preparations will include other students and teachers. Ms. Cunningham said studies, in which students will help, may include obtaining information on soil depth and temperatures, and taking core samples of trees for discovering the age of some of the older cedars on the site.

BIOGRAPHY

ALVIN W. TRIVELPIECE

Alvin W. Trivelpiece became the Director of Oak Ridge National Laboratory (ORNL) and a vice-president of Martin Marietta Energy Systems in January 1989. Trivelpiece oversees the research and development programs and associated support operations at ORNL, one of the Department of Energy's (DOE's) multiprogram energy laboratories. Activities at ORNL include applied research and engineering development in support of DOE's fusion, fission, conservation, and fossil energy technology programs and basic scientific research in selected areas of the physical and life sciences. These activities involve a staff of over 5000 and a budget of approximately $500 million.

During 1987-88, Trivelpiece served as the Executive Officer of the American Association for the Advancement of Science. From 1981-1987, he was the Director of the Office of Energy Research at DOE. Trivelpiece was corporate vice president of Science Applications, Inc., in La Jolla, California, from 1978 to 1981, and from 1976 to 1978 he was vice president for engineering and research at Maxwell Laboratories in San Diego, California.

Trivelpiece was a professor of physics at the University of Maryland from 1966 to 1976 and was a professor at the University of California, Berkeley, in the Department of Electrical Engineering from 1959 to 1966. While on leave from the University of Maryland, from 1973 to 1975, he served with the U.S. Atomic Energy Commission as assistant director for research in the Division of Controlled Thermonuclear Research.

A native Californian, he received his B.S. degree from California Polytechnic State University in 1953, and his M.S. (in 1955) and Ph.D. degree (in 1958) from the California Institute of Technology.

Trivelpiece was a Fulbright scholar in the Netherlands from 1958 to 1959 and a Guggenheim Fellow in 1967. He was named Distinguished Alumnus of California Polytechnic in 1978 and of the California Institute of Technology in 1987.

His research has focused on plasma physics, controlled thermonuclear research, and particle accelerators. He was granted several patents on accelerators and microwave devices. He has published many papers in his field, and is the author of two books on plasma physics.

He is a fellow of the AAAS, the American Physical Society, and the Institute of Electrical and Electronics Engineers, and is a member of the American Nuclear Society and Sigma Xi.

Ms. LLOYD. Thank you very much, Dr. Trivelpiece. Dr. Springer, please proceed.

STATEMENT OF DR. ROBERT W. SPRINGER

Dr. SPRINGER. Madam Chairman, members of the Subcommittee, I am extremely pleased by the Committee's interest in this subject in the role of the National Laboratories in science education and it is indeed a privilege to be here and be able to share with you my perspective on that from the point of view of having worked at Argonne now for eight years.

It seems to be generally agreed that the national labs are a scientific resource of enormous magnitude, which can really have a significant impact on science education at all levels. Dr. Trivelpiece has mentioned that he feels the labs are under-utilized in that regard and I certainly reinforce that.

Argonne, for example, has the largest program among the DOE laboratories and we have considerable more capacity than is now being used.

Ms. LLOYD. As you know, Congressman Schiff and I visited Argonne, we were there in February.

Dr. SPRINGER. Yes.

Ms. LLOYD. And I was most impressed with Dr. Lederman's program on Saturday morning for the young scientists, the bright high school students from the area, that participate in the program. You certainly are to be congratulated. I hope that you continue the program since Dr. Lederman is leaving, with renewed interest.

Dr. SPRINGER. You will learn about that this afternoon from the representative from Fermi Lab that will be here.

Mr. SCHIFF. I just want to add that although I represent a district in Albuquerque, New Mexico, my wife and I are natives of Chicago, Illinois. My wife is a graduate of the University of Chicago which manages Argonne, and if I even think of doing something too adverse to Argonne, I assure you I hear about it at the dinner table.

Dr. SPRINGER. Well what I would like to do is convey to you something of the nature of what we are doing and why and also some sense of what more I think we could do, and try to provide you with a measure of not only what can be done at national labs, but what more can be done for science education.

We shape our program to a great extent by the context in which we operate. We are located, as you know, very close to the city of Chicago and in those vast suburbs around it, so we have a great opportunity for programming in the precollege area, particularly that directed at the minority population in the city. The Laboratory is also right in the middle of a very rich supply of educational institutions of higher education as well. This ranges everywhere from the small liberal arts colleges that are so popular in the midwest up to major research universities, private and public, some of the most prestigious in the country. And so we feel a responsibility for and there is an opportunity there to support science education at that level as well.

In particular what we want to do—that is the major role of our program—is to provide this large population of faculty and students with regular contact with the type of exciting, cutting edge research and big science that goes on at the national labs. This requires obviously a large scientific resource such as a national lab and a lot of interested people.

As a major multi-purpose research lab, Argonne has the physical resources that you became acquainted with out there, and as to personnel, the Department of Energy in general and Argonne in particular, have a long history of involvement in education, which you have heard comments on already, since essentially the origins of these organizations. This has the important consequence that participation in these programs is a normal, expected thing. It is part of the culture at Argonne and also at the other laboratories. The degree of cooperation we get as a result of this from the research staff is extremely high and that provides us with the personnel resources we need, and of course that is critical.

So there is an opportunity there and a responsibility adequate scientific resources, physical and human, and of course we also need the financial resources.

Funding for these programs is obviously something that is on everyone's mind today, so let me comment a little bit on that. Most of the funding for programs at Argonne is provided by the Department of Energy under the umbrella concept that Ms. Joseph mentioned, the Science Education Center. The Department now supports these Centers at six laboratories and the main idea of the Center is that the program is viewed and funded as a whole rather than as a collection of unrelated individual programs. That is important when one is trying to support science education at as many levels as we are, to have the flexibility and the possibilities for program integration that the Science Center idea allows.

As to the level of funding, it has gone through a series of plateaus, in my experience anyway. For a period of something like ten years—this was awhile back—the funding for these programs was fixed, it was level and it was well below that needed to provide programs at all levels and also to have a real impact on science education, given the size of the student and faculty population in the country. We had essentially no programs in the precollege area and our ability to provide research experiences for undergraduates and research opportunities for graduate students was quite limited.

That began to change about four years ago and since then funding for our program has increased, and we have been able to add important new programs that you have heard something about, at the precollege area and also in the undergraduate level. Unfortunately, even though we all recognize an increasing need for these sort of things, we are at another funding plateau. There is no increase for these programs in 1989 and there is none projected for 1990. And as I indicated earlier, we have considerable more capacity than is now being used. Not only that, but increases at this point, given the infrastructure already being established, the increases go primarily into having more participation from faculty and students. The programs at Argonne, in my judgment, could easily be effectively and efficiently doubled in size. I think that is a reasonable measure.

Also I want to outline certain of the programs we are doing, trying as much as I can to not duplicate other comments.

I certainly endorse the idea that we have to reach down as low as possible in the precollege area to try to stimulate interest in science and awareness in science and to try to do that for a large number of students, and that creates one difficulty for us, because it is difficult for us to bring large numbers of precollege students in the lower grades to the lab for long periods of time. There are alternatives to do that though and that is you simply form some partnerships. One way we can do it is to work with teachers and the other way is in a partnership with colleges and universities.

You have heard mentioned the high school teacher associates program this summer. Argonne is participating in that and a significant portion of our appointments there will be for teachers in the city of Chicago and we will be combining that with other elements of our program to provide in-service training, teacher institutes, summer institutes and so forth. And all of it working toward providing a support network for teachers in the region and in the city in particular. So we would like continual contact with these people and for them to feel that they are not in that high school with the large teaching burden and a low budget without any support at all, that they have a network of their peers and they have people that they can ask for support at the laboratory.

We have had small programs for high school students for eight or nine years. This is about 40 or so high school sophomores and high school seniors that come each summer. In order to try to expand these programs and involve the large numbers of students that I mentioned I think are necessary, we formed a formal cooperation with Chicago State University, that is primarily a minority institution in the city. And we are currently discussing a similar sort of arrangement with Northwestern University.

We have had a large summer program for undergraduates for many years and I want to emphasize also the importance of continuing that. It is in this undergraduate research participation program we call it, that the students that we do get interested in science really get to find out what a research activity and real science is all about, and find out whether they really like it and they are influenced in the sorts of fields that they choose and get a firsthand taste of what it really would be like to do it. It is that time where I think their minds are really made up.

Sometimes we hear that our efforts to increase participation in science ought to be focused a lot more at the precollege level, I think we should have certainly a lot more than we now have there, but we need to maintain the undergraduate and graduate programs as well. The demand for our undergraduate program is extremely high. We typically place 200 students each summer in our undergraduate program. We have applications from somewhere between 1,200 and 1,500, so the demand for this is very high. And it is in response to this sort of thing that the Department formed the semester program a few years ago. That will enable us to provide opportunities to a much more significant portion of these interested students.

And then having stimulated hundreds of students every year to go on to graduate school and pursue research careers, it is only natural that opportunities also need to be provided at the graduate level. As Ms. Joseph mentioned, that is done a lot directly with universities, but there is also a need for programs at the laboratories. We have 60 or 70 graduate students at the lab at any one time doing thesis research and primarily they are there because the equipment that is available at the lab for their research is not available at their home institutions, and that is an important role for the national labs to play in that area.

It is also important for us to provide opportunities for faculty, not only faculty who are interested in research but faculty who are interested primarily in teaching. For both of those, there are appointments available to again come and participate in research. We also operate a large series of workshops and faculty institutes that give them periodic updates on current developments in research, given them an introduction to the facilities and programs at the lab that they can later participate in.

Finally, we also provide teaching and research faculty in our region with access to instrumentation at the lab. Instrumentation again is another major problem facing educational institutions at all levels and research facilities and equipment is again something that is in good supply at a national laboratory, so we try to facilitate access to equipment that is in the research divisions and also in our own small teaching laboratory.

So I will simply conclude then by reiterating that I think the national labs have a great deal of unused potential for support of science education at all levels. We are very pleased that this has been recognized by the Committee and that the Committee is interested in finding ways of making greater use of this resource. I would be glad to answer questions and provide you with any further details you might need.

[The prepared statement of Dr. Springer follows:]

Testimony Before the

SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT OF THE HOUSE COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY U.S. HOUSE OF REPRESENTATIVES

Chattanooga, Tennessee

ARGONNE NATIONAL LABORATORY • UNIVERSITY OF CHICAGO

by

Dr. Robert W. Springer
Director of Division of Educational Programs
Argonne National Laboratory

May 15, 1989

Madam Chairman and Members of the Subcommittee, I am extremely pleased by the Committee's interest in the role of the national laboratories in science education. It is a privilege to be able to provide you with my perspective on that role, based on being Director of Educational Programs at Argonne for the past 8 years and a faculty member and department chairman in a university engineering program for 15 years prior to that.

The national labs are a scientific resource of enormous magnitude which can make important and, in many ways, unique contributions at all levels of science education. They are greatly underutilized in this regard. Argonne has the largest program among the DOE labs, and we have considerably more capacity than is currently being used. I hope to convey to you the nature of what we are doing and why, and some sense of how much more we could do. This should provide you with one important measure of what and how much can be done for science education at national laboratories.

The context in which we operate at Argonne naturally influences the nature and the scope of our program, both in general and in detail. Argonne is located very close to the city of Chicago and in the midst of its vast suburbs. Accordingly, we have a unique opportunity among the DOE labs and with it a serious responsibility for programming in the pre-college area, particularly that directed at the large minority population in the city. The Laboratory is also within a few hours of a very large number of institutions of higher education, including many small, high quality, undergraduate liberal arts institutions, and some of the nation's most prestigious research universities, both public and private. Both, as you know very well, play important roles in science and engineering education at the undergraduate and graduate levels. It is therefore also important that we support science education and research at these stages as well. In particular, it is essential that as many as possible of this huge population of faculty and students have regular contact with the type of exciting, cutting edge research and "Big Science" that are the national labs' stock in trade.

The overall goal of Educational Programs at Argonne is therefore to offer programs that provide this contact in a variety of ways, and in a broad range of scientific and engineering fields for faculty and students at virtually all levels.

Such a task obviously requires a large scientific resource and many interested people. As a major multi-purpose research laboratory, Argonne has the physical resources that are needed. As to personnel, the Department of Energy, in general, and Argonne, in particular, have long histories of national and international educational programs that go back almost to the beginnings of these organizations. This has the important consequence that participation in educational activities by the research staff is a normal, expected thing. It is part of the culture at Argonne and at other DOE labs. The degree of cooperation we get from the research staff is therefore extremely high and provides us with the personnel resources that our goals require.

So there is need and opportunity, there is responsibility, and there are adequate scientific resources, both physical and human. Dollars are also necessary for student and faculty stipends, for materials and for effort on the part of staff from my Division. Funding for these programs is obviously something that is on all of our minds here today, so let me move to that.

First, I want to note that most of the funding for educational programs at Argonne is provided by the Department of Energy under the umbrella concept of a Science Education Center. The Department now supports such Centers at six of its laboratories (in addition to supporting individual programs at other labs). The main idea of a Center is that the program is viewed and funded as a whole rather than as a collection of separate, individual programs. It is very important when one is trying, as we are, to support science education at all levels and in many ways, to have the flexibility and the possibilities for program integration that the Center concept allows.

As to the level of funding, the history and current situation is briefly the following. For a period of something like 10 years, funding for these programs was fixed and well below that needed to provide programs at all levels and on a scale that would result in a real impact on science education. We had essentially no programs in the pre-college area and research experiences for undergraduates and for graduate students were extremely dollar-limited. This began to change about four years ago. Since then, funding for our programs has increased, and we have been able to add several important new programs, particularly in the pre-college area, and also expand undergraduate programs considerably. Unfortunately, even though the need for programs of this sort has become greater and increasingly recognized, we have hit another funding plateau. There was no increase for education this year and none is projected for FY90. As I indicated earlier, we have considerably more capacity than is now being utilized. I believe that we could effectively and efficiently double the size of our current program. I want to emphasize that because our organization and our programs are, for the most part, in place, funding increases at this point will largely be used to increase student and faculty participation.

At this point I want to briefly outline what we are doing at each level in more specific terms, and what we estimate our capacity to be in each case.

It is important that we stimulate and support interest in and awareness of science from an early age, and to do so for a large number of students. The further one reaches into the lower grades, the more students one has to address. We have limitations on our ability to bring large numbers of very young students to the Laboratory for long periods of time. But there are alternatives which still enable us to reach large numbers of students. One is to work with teachers. The other is to work in partnership with colleges and universities. We are doing both.

The Department of Energy has initiated this year a new national program for high school science teachers which will bring 20 teachers to our Laboratory for the summer. During the coming years, we plan to combine first-hand participation in research during the summer through this program with a variety of workshops and teacher institutes during the academic year to build a continuing support network for science teachers. A substantial portion of this effort will be directed at teachers in the city of Chicago. Through this support network, teachers will be able to increase and renew their knowledge of science, to stay current with exciting new developments, to arrange for class tours, and to bring interesting guest lecturers and demonstrations to their classrooms. We can accommodate twice the number of teachers that this new program will support and, along with several other labs, we are seeking additional support for this from the National Science Foundation. If we are successful, teachers from lower grades will be included in the program. We also could offer at least twice as many In-Service programs and teacher institutes as current funding levels allow. Personally, I think this is one of the most important programs we can have. Teachers of science at the middle and high school levels can have a tremendous impact on students' interest in science, but they work in most difficult circumstances. Any support we can provide them is greatly appreciated and will pay great dividends.

We have provided small programs at Argonne for high school sophomores and seniors for the past eight years or so. Approximately 40 students are involved in each. In order to expand these programs to involve more students, we have recently established a formal cooperation with Chicago State University, which is a predominately minority institution in the city. We are also currently discussing a similar arrangement with Northwestern University. The advantage of these cooperations is that, while we cannot accommodate large numbers of pre-college students at the Laboratory, universities can. They have classrooms and laboratories that are ideal for this purpose and which are vastly underutilized during the summer months. They also have a high interest in attracting students, particularly minority students, to their science and engineering programs. The partnership is thus a natural one. The cooperative program we are planning will consist of a major outreach effort at the lower grades, primarily directed at stimulating and sustaining student interest in and awareness of science. As shown by the photograph which was enclosed with my testimony, this can be done with very simple experiments. In this case, students are observing the levitation of a superconducting disk. As the students progress to higher grades, they will be invited to participate in summer classroom and laboratory programs with more emphasis on content and hands-on experience. Argonne will support both the outreach and the summer programs, both administratively and scientifically. All participants will be brought to the Laboratory for special events. Funding currently available is well below that needed to implement these programs on the scale that is possible and is needed.

Argonne has had a large summer program for undergraduates for many years. This is part of one of DOE's major national programs. Through this program, students with an interest is graduate study and a research career get an opportunity to see what is really like by actually participating in advanced research under the guidance of an individual research scientist. We sometimes hear that efforts to increase the number of students taking up careers in science should be concentrated entirely on the pre-college level, that by the time students reach the undergraduate level their minds are already made up. Our experience indicates that both are needed. At the undergraduate level we do find students with a definite interest in science and engineering, but they know very little about the excitement and rewards of research. Also, they are being attracted to other fields in which rewards seem to be greater and the path easier. The fact that many are now choosing alternatives to science and engineering has been verified by many recent studies. A recent formal evaluation of the DOE undergraduate summer program nationally has documented that it is extremely successful. Five years after completion of a summer program at a DOE lab, 90% of former participants indicate that they either have or will soon receive an advanced degree. Moreover, more than 60% indicate that this program was a significant influence on their doing so and on their choice of field.

The demand for DOE's undergraduate research participation program is extremely high. At Argonne, we get between 1200 and 1500 applications from honors caliber undergraduates every summer. We are only able to accommodate about 220 and current funding restricts us to actually placing about 200. In order to provide opportunities to more of these students, DOE initiated a new program two years ago called the Science and Engineering Research Semester (SERS). This program provides undergraduates with opportunities to participate in research during the academic year. The program is designed to be the science analog of the off-campus and semester abroad programs that have been an established part of non-science curricula for many years. The research experience is supplemented with seminars and, as needed, with academic courses taught by college and university faculty. Students who want credit for this experience are generally able to obtain it from their home institutions. Students prepare reports on their research, and some are able to present their work at national student research conferences. Many are listed as joint authors on papers submitted by the team to scientific journals. Argonne currently places about 65 students at the Laboratory in this program each semester. We could accommodate approximately 125 if additional funding were available. Recently, we have begun arranging for faculty and small groups of students to participate in this program as a team. This adds considerably to the educational component of the program. Again, however, current funding levels limit SERS to about one-third of what would be useful.

Having stimulated hundreds of undergraduates to go to graduate school each year, it is naturally appropriate to also provide programs which support graduate education and research. DOE does this to the greatest extent through direct support of research at universities. In addition, however, the national labs also provide opportunities for graduate student thesis research. This is particularly important when special experimental equipment needed for the research is not available on campus, but is available at the Laboratory and these days, when experimental facilities can be extremely expensive, this is often the case. Approximately 70 students are actively engaged in full scale thesis research at Argonne at any one time, and about half this number are also doing parts of their thesis with equipment on-site. Both of these numbers are well below demand and our capacity. Funds available for thesis research this fiscal year were fully committed by late January. We estimate that we could accommodate at least twice the number or graduate students we now have and that this would still not satisfy demand.

It is also important to provide opportunities for faculty to participate in laboratory research. This is clearly one of the best ways to involve faculty in DOE's research programs, particularly in the early stages of their research careers. Many faculty at primarily undergraduate institutions try to sustain an active research program in spite of heavy teaching commitments. It is important for these faculty to do research. A collaboration at a national lab can be of great value in this effort. Frequently, participation in a summer or sabbatical leave program at Argonne or another DOE lab leads to a joint research proposal and a continuing collaboration. These partnerships thus spawn research programs on college and university campuses which then involve even more undergraduates in research, either on campus or again in one of the laboratories. We now have about 70 faculty members conducting research on-site during the summer and 10-15 on sabbatical leave during the academic year. Capacity at Argonne is estimated to be approximately 130.

My Division also sponsors a series of 20 to 25 workshops and conferences which supplement these programs for individuals in important ways. I have already mentioned In-Service programs and Faculty Institutes for pre-college teachers. Faculty Institutes focused on recent research results are also provided on a regular basis for college faculty with a primary interest in teaching. Workshops which present the capabilities of the major experimental facilities at the Lab, which the Department makes available to university faculty, are also a regular event. We would like very much to be able to expand this series by about 25%, particularly in conjunction with the new pre-college outreach and teacher network programs I described earlier.

Finally, we also provide teaching and research faculty with access to instrumentation available at the Lab, but not on many campuses through a Regional Instrumentation Sharing Program. This is done on an individual, special arrangement basis. There is considerable demand for this program, particularly from faculty at nearby small colleges which have little hope of acquiring extensive laboratory facilities themselves. Funding for this program could usefully be increased by a factor of 2 or 3.

I will conclude by reiterating that the national laboratories have a great deal of unused potential for the support of science education at all levels. We are very pleased that this has been recognized and that the Committee is interested in finding ways to make greater use of this resource. I would be glad to respond to questions and to provide the Committee with any further details it might require. Thank you.

BEST COPY AVAILABLE

Ms. LLOYD. Thank you, Dr. Springer. We will withhold our questions until all our panelists have concluded their statements. Dr. Perry, we now look forward to hearing from you. You may need to move that microphone closer to you since we are sharing today.

STATEMENT OF DR. MANUEL PERRY

Dr. PERRY. Thank you. Chairman Lloyd, Mr. Schiff, I very much appreciate the opportunity to come here and appear before you today.

As you are aware, the Lawrence Livermore National Laboratory is one of the largest and in my view one of the best science and technology research facilities in the world. We employ over 9,000 scientists and technical support personnel at our organization.

One of my responsibilities as manager of the planning and development group at the Laboratory is the study of changes that affect our ability to recruit and hire individuals. What I see is a rapid diminishment of the pool of qualified young and interested scientists and technologists coming into the professions.

I know that there is no need for me to spend time and try to convince this Committee of the critical need of the immediate and full scale effort to raise the level of science education in our Nation's schools, that's the reason we are here today. There is also no need for me to remind you of the scientific excellence of the national laboratories. But what does need pointing out is the disconnect that presently exists between these centers of excellence and our schools.

A profound and widening gap exists between the scientific community and the general public, and this gap has created a work force that does not possess an up to date awareness of the current status of scientific and technical knowledge. Such a lack of scientific and technological literacy creates apprehension and distrust at the very moment this country most needs the creativity and the enthusiasm of well-informed, well-educated young scientists and technologists.

To continue to depend upon present scientific community to meet the current and the future international competition in science and technology, while ignoring those who will replace them, is to eat our own seed corn. The American scientists and technologists of the 21st century are in our schools now. We need a strategy to engage the whole, entire scientific community and especially those at the national laboratories in the process of reclaiming science education.

I propose that the quickest and the most effective solution to this dilemma is to replace the disconnect with an efficient, smooth-functioning collaborative connect between our schools and our centers of scientific excellence. Such a union will ensure the quality of future scientists and technologists and the future is with us now.

As you know, most of the national laboratories are already involved in independent programs designed to support science education in our own areas. For the last 20 years, Lawrence Livermore Laboratory has developed and run many successful education outreach programs in an effort to narrow the gap. During these 20 years, we have developed over 86 education outreach programs, 60 plus programs are active today. We have education programs for students, for teachers and administrators. Our student programs involve students K through 8, high school, community colleges and universities and post-doc. Our faculty programs involve teachers from elementary schools, high schools, community college, college and universities. Our goals for our programs are key. Having science and technology experienced as an interesting, fun and an achievable activity; having hands-on science of hear, see, as well as do, having science and technology seen as inter-related and that present walls between the two disciplines of science and technology, having them come down. And having all students, all races and both sexes, understand that they can achieve and that they are welcome in the field of science and technology.

Our commitment to education programs is unique. If it is important to the laboratory to do it, then we will find a way to get it done.

I admire and applaud the efforts that we have undertaken over time as well as those of the other laboratories. But I also know that such independent programs engender duplication, unevenness of effect and slow progress. Laboratory-specific programs tend to be diffuse in subject matter, generally unknown outside their own region, uncoordinated and lacking in continuous funding.

Scientists and technologists participating in these programs are often not recognized as performing a service to education commensurate with their programmatic contribution. Consequently many people participate at a risk to their career.

Let me now close by making some recommendations. I recommend that Congress establish a policy endorsing the legitimacy and the necessity of science education activities by all program areas of the national laboratories. Such a mandate from Congress would underlie the stated commitment of this administration to education.

Also I recommend that Congress provide sustained educational outreach funding at a level which will ensure the continuity of effective programs.

For the national laboratories, I make these recommendations, that we involve staff members from all disciplines; scientists, technicians, crafts persons, in education outreach programs aimed at narrowing the gap, that the national laboratories provide the time, the dollars and the recognition for employees to develop quality ongoing education programs, and that the national laboratories serve as regional centers, providing quality educational programs in their own areas articulated with their own schools, and then finally that the national laboratories collaborate with other scientific laboratories to develop a system to exchange information, effective programs and educational materials.

These recommendations, directed nationally, using the highest level of scientific expertise found in our laboratories as resources to our schools, and receiving continuous funding, will begin the turnaround in scientific and technical education in this country. If such recommendations are instituted by the present administration, and if the involvement of laboratory scientists and technologists is recognized as an important part of our professional responsibility, we can do again what we did in the 1950's faced with Sputnik and similar educational dilemma.

I strongly urge this Committee to put these recommendations in place as soon as possible.

Ms. LLOYD. Thank you, Dr. Perry. All of this testimony is rich and is well prepared and I want to congratulate all of you.

Bill, we look forward to your testimony as equally informative. Please proceed.

[Materials submitted by Dr. Perry follow:]

On the Front Lines of
SCIENCE EDUCATION

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On the Front Lines of Science Education

A cluster of curious fourth graders gathered around Lasers' Jay Wiedwald as he used a strip magnet to line up iron filings. In a flash of inspiration, one boy asked, "Is that the way a tape recorder works?" Wiedwald was astonished. "After that, I had to come back for more," he says.

Lab employees like Wiedwald have been coming back for more since the late 1960s, helping Bay Area students and their teachers appreciate the excitement and fundamental concepts of science and technology.

Some contribute through workshops sponsored by their divisions or through the Lab's Science Education Center (SEC). Others do it less formally, by explaining a scientific concept in their child's classroom, or by tutoring a student in mathematics, sponsoring a student or teacher for the summer in their own department, serving on curriculum advisory committees, or mentoring students who want to pursue careers in science and technology.

For many years Lab employees have been on the front lines of America's battle against scientific illiteracy. Today the United States is seeing its long-held scientific pre-eminence challenged by Japan and Western Europe as never before. The underlying reason, say many experts, is that schools are not turning out students well educated in science and technology.

The disturbing trends are seen in colleges with declining enrollments in disciplines like physics, chemistry, and computer science. But the problem is evident most dramatically in pre-college education. Until the eighth grade, students are lucky to have any real exposure to science. The science they do receive is taught by people who have little training in the subject and who enjoy few support facilities or resources.

Notes the Science Education Center's Hector Timourian, "Most teachers in elementary and middle schools don't feel comfortable with science. For many, their only exposure to science in college was a course in biology, which often requires learning a greater vocabulary than a beginning language class."

As a result, children end up with little understanding of the technological world in which they live. "They become turned off to science at an early age," says Timourian. "By the time they reach high school, the easiest thing to do is avoid science courses altogether."

Human Resources' Linda Lucchetti used to teach elementary school in Massachusetts. She attended a teachers' college in that state, where in four years she received only a brief course in how to teach science. "I had a basic liberal arts background, and I felt totally unprepared to teach science.

"I got really excited when I learned the Lab is willing to have people volunteer to help teachers. As a former teacher, I want to stay connected with my former profession and I know that elementary grades are crucial for the kids to get the spark going."

Science education fares no better in most American high schools. Statistics show that fewer than half of all U.S. high school students take three years of math and science; virtually all secondary school students in both Japan and West Germany take at least three years.

The discrepancy between U.S. and other industrialized nations' science education achievements is seen in a recent

Manuel Perry, head of Human Resources' Planning and Development Group, says Lab educational outreach programs assist in training LLNL's future workforce.

Former college physics instructor Camille Minichino (left), now a SEC staff member, talks with educators at a Science Education Center workshop. She contends that a good teacher can teach quantum mechanics to kindergarteners.

international survey of high school seniors. Out of 13 nations, American students ranked eleventh in chemistry, ninth in physics and last in biology.

The nation's $135 billion a year public school systems are responding, however. They are raising teacher salaries to attract more people with science backgrounds, toughening graduation requirements in math and science, and experimenting with new teaching methods and longer school years (most American schools are in session for about 180 days, compared to the 210 day or 240 day school-year abroad.)

A number of myths have contributed to the poor image of science among students. One is that science has little relevance to daily life. Physics' Bill Chandler visits high schools to help dispell this belief by asking students what they consider to be the most important issues in society.

"Usually two-thirds are science related," he says. "I tell students that if we are going to make it as a society, we have to solve these problems with the best science and technology at hand. You can't understand the world without understanding science."

In many schools another myth effectively discourages many students from even considering taking science classes. It is that science classes are too difficult for most students and are really only for the elite.

A study reported at a recent meeting of the American Association for the Advancement of Science shows the typical scientist depicted on television speaks with a foreign accent, wears a white lab coat, is male and white, wants to rule the world, and often gets injured or killed.

The SEC's Timourian points to a magazine cartoon in which a scientist introduces his young son to a colleague and says: "Elton wants to be a scientist when he grows up, but I'm not sure he's weird enough."

Says Timourian: "Scientists and educators, as partners, must work to dismiss these, and other misconceptions."

Some educators assert that if science is often boring and difficult, it is in the way it is presented. San Francisco City College physics professor Paul Hewitt says the "killer" courses in high school are the science courses. "They diminish the students and lower their self-confidence. Students say, 'I made it through but I didn't learn anything.'"

Hewitt, who addressed LLNL employees earlier this year at an SEC workshop on science education, is trying to revolutionize the teaching of physics. He contends that many high school students are turned off to physics because their teachers often plunge immediately into complicated mathematics. In contrast, Hewitt's classes downplay math in favor

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of presenting basic physics concepts.

"Students learn that there are reasons for everything, that physics can be interesting, fun and understandable," he says. "It can then lead to chemistry and biology."

Chemistry's Ken Foster agrees with Hewitt's contentions. "I was capable and bright enough, but I just didn't try. Math and physics were considered only for the elite."

Foster became "hooked" in Hewitt's conceptual physics class. Within a few weeks, he knew science would be a part of his life's work; he eventually earned a degree at San Francisco State University.

LLNL Human Resources planners note that co-incident with the declining appeal of science and technology to young people is a growing demand for skilled workers. They say the declining standards in technological competence come at a time when a changing national economy is requiring workers to cope with an increasingly technological workplace. A new U.S. Department of Labor study, *Workforce 2000*, says the new jobs of the coming decades will demand much higher skill levels than the jobs of today.

Manuel Perry, manager of Planning and Development in Human Resources, says the Lab must develop better strategies to insure a constant supply of new talent. That means developing strong college and university relations as well as placing greater emphasis on impacting elementary, middle and high schools.

Perry notes that the Lab has a long history in working to improve local science education. In 1969 the Lab began LESSON (Lawrence Livermore Elementary School Science Study of Nature), a two week workshop. Since then more than 1500 teachers and 45,000 students have been exposed to LESSON.

The LESSON program has been offered in many other states and last summer was offered in the Virgin Islands for the first time, notes Karol Ruppenthal, manager of the Lab's Affirmative Action Programs Division in Human Resources.

Today the Science Education Center is increasingly the focus of LLNL pre-college outreach efforts. The SEC is located at the old Almond Ave. school in Livermore. Hundreds of teachers have attended SEC-sponsored workshops while more than 5000 students have been reached by SEC and LLNL instructors.

A popular program offered by the SEC is the Computer Learning Center. It offers a wide range of classes, workshops and self-guided tutorials on the facility's

Developing a lesson on the environment for second graders brings SSI participants to their knees. (A)

An SSI team designed a game that teaches [illegible] [illegible] blend with the environment. (B)

Teachers plan a lesson that will show students how to dispose of household materials properly. (C)

SCIENCE EDUCATION

Science Goes to Elementary School

"Discovery learning" is the way Hector Timourian of the Laboratory's Science Education Center describes the activities of the four-year-old Summer Science Institute (SSI).

During this year's month-long program which started in mid-June, elementary school teachers from the Bay Area attended "enrichment lectures" given by LLNL scientists, engineers and technicians, and participated in laboratory experiments. From these experiences they developed lessons based on the scientific concepts involved.

Then, they tested the lessons in Livermore summer school classrooms, instead of just fashioning them.

From these lessons, the best will be chosen, edited and shared with teachers in other parts of the country.

The National Science Foundation co-sponsored this institute with LLNL.

IBM, Apple II and Plato courseware. They are taught by the SEC's Stephen Sesko, who says the prime goal is to help teachers and students overcome fears associated with using computers.

Central to SEC programs are Lab researchers who contribute their expertise and enthusiasm to a Bay Area classroom or teacher workshop.

"There are hundreds of schools out there that need our help," says Timourian. "We in the research community are at the frontiers of science and technology. We can explain what it's all about better than anyone. With very little effort we can make a big difference to a classroom and a school."

The SEC's Camille Minichino says one of the factors in the Center's success is its commitment to a school or classroom or teacher that receives SEC help. "We don't go into a classroom, amaze the students with a 'gee-whiz' demonstration and then leave. We come back several times and ask the teachers and students for feedback so we know if we've been effective."

SEC workshops are well-known to Bay Area elementary and middle school teachers. The workshops provide hands-on experiments and projects with everyday materials teachers can adapt to their own classrooms. The workshops also offer credit through California State University at Hayward.

An example of a workshop is the Summer Science Institute (SSI), a month-long program to help local elementary school teachers gain confidence teaching science. Co-sponsored by the National Science Foundation (NSF) and aided by Livermore School District Science Resource Specialist Don Iman, the institute shows teachers how to develop lessons based on subject material presented by Lab speakers. The lessons are then edited, printed and made available to other teachers and school districts. During the school year teachers receive follow up workshops and in-class support from the SEC staff.

Physics' Bill Chandler has been helping with the SSI for three years. "It's an outstanding program," he says. "Teachers become extremely enthusiastic; they see teaching science can be fun, simple and inexpensive."

With NSF funding, the SEC staff has helped start SSIs in Brevard County, Florida, in cooperation with the Space Coast Science Center at Cape Canaveral and in Western Massachusetts in cooperation with North Adams State College. Others who have shown inter-

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The SEC's Hector Timourian (center) says that scientists and pre-high school teachers must be partners in science education.

est are school districts in Florida, New York and California and Villanova University in Philadelphia.

"My dream is that this type of teacher enhancement will start in a lot of places throughout the nation," says Timourian.

Another SEC-managed workshop took place last summer in Lab research facilities. Initiated by G-Division's Joe Knox and Mike MacCracken and funded by the DOE Carbon Dioxide Research Division, the teacher-training workshop addressed issues related to global climate changes caused by the buildup of carbon dioxide in the earth's atmosphere. In an effort to show how science impacts other fields, the workshop had social science and art as well as physical science teachers participating.

When the SEC was made part of Human Resources' Planning and Development Group early this year, it became an even greater focus for Lab outreach educational activities. Perry says the challenge now is to work with Lab departments and divisions to "coordinate, collaborate and cooperate" on the various programs the Lab now offers.

"There are many educational outreach activities going on within Lab departments," he notes. "Many of these programs will serve as the cornerstone for developing strong relationships with colleges and universities as well as for developing programs to train the future workforce the Lab will need."

A very popular department outreach program is Mechanical Engineering's Summer Institute for Mechanical Technology. Jointly sponsored by Mechanical Engineering, Human Resources and the California State Department of Education, the institute is designed for college and high school teachers. Although the only advertising was word-of-mouth, this year more people applied than the workshop could accommodate.

ME's George Tokunaga, institute coordinator, explains the workshop's popularity: "Technical teachers are fighting a battle of declining enrollment in their courses. Many teachers aren't able to get out in industry and see the application of their instruction. For example, many are teaching geometric dimensioning and tolerancing, but don't really know how it applies to industry.

"We have Lab machinists, technicians, coordinators and drafters explain what they do and the new technologies they use. Our goal is to help give the kids a knowledgeable choice by letting them know what technical careers are available."

Many other Lab departments are coordinating similar outreach programs out

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of the SEC. One standout is Lasers' Inertial Confinement Fusion (ICF). Deputy Associate Director for ICF Erik Storm developed a fusion energy education program which encompasses both laser and magnetic fusion energies. The program has received national recognition for its school visits, teacher workshops and excellent supporting materials.

The program is led by Don Correll, program leader for fusion technology and public information, with the assistance of the SEC's Minichino. Correll said the reaction from both students and teachers has been overwhelming. "We have a whole drawer of thank you letters. Students really appreciate getting to talk to actual scientists."

Correll also says that he discovered that teachers don't have many resources. "They get a lot of mileage out of a photograph or slide we provide."

Minichino, a former college physics teacher, contends that no scientific concept is too hard for kids. While the math or technology involved may be difficult, a good teacher, she says, can explain quantum mechanics to kindergarteners.

She says the process of fusion is particularly simple to teach. "You take two light atoms and fuse them to give off energy. For high schools, you bring in the periodic table and introduce fusion technology. For colleges, you present much more math and chemistry. You're still telling the same story; you just scale up or down in complexity."

Correll and Minichino have co-authored a short high school text for both teachers and students. Entitled "Fusion Energy: Meeting the Challenge," it has become very popular with teachers across the country. Argonne National Laboratory is transferring the text, complete with graphics, to a personal computer diskette for distribution to the nation's high schools. The computer version will also be made "interactive." For example, students will know immediately if they choose the right answer to a problem.

Minichino says that once intrigued about science, students are hungry for more information. She recalls a recent request for additional material from a fourth grade girl who wanted to teach her parents the concepts of fusion.

Perry says that "Lab people have a special responsibility to help define and raise scientific literacy and share their excitement about and knowledge of scientific research. They also have a responsibility to assist in developing the people who will someday replace them."

—*Arnie Heller*

Art in Science

It began with a rather simple question: Can you use art to teach science?

From this came a Lab [illegible], education oriented, pilot program at the Claremont Middle School in Oakland last summer.

Called Art in Science, the program focused on introducing science and technology to five teenagers with artistic talent. Using their flair for drawing as the centerpiece, the program encouraged them to reach out in other directions—namely history, English and science.

"Educational outreach at the Laboratory is most often thought of in terms of high school and college students," says Perry, who [illegible] the program. "But we have to help educate young people, the kids, most of whom don't know what technology is. They need to know what's happening tomorrow, and what skills they'll need to develop to survive in a technological world."

The youths were chosen by their art teachers to participate in the two-week program, which ran from July [illegible] to July 18.

During nine half-day sessions, the young artists researched notable discoveries made by [illegible] scientists and inventors in the history of science and technology, wrote brief biographies of the individuals and descriptions of their inventions, and rendered portraits of the innovators using a variety of illustration techniques.

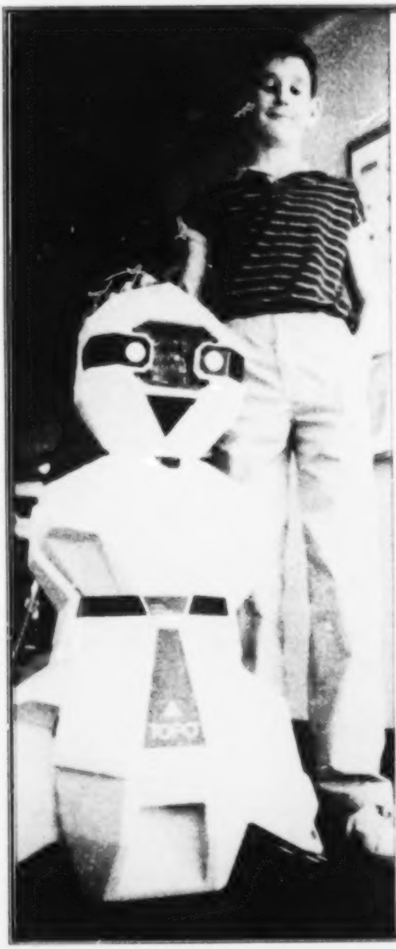
The illustrations and written material are being reproduced on a series of posters, which will be used as recruiting and educational outreach materials by the Laboratory.

The class was taught by Tom [illegible], a graphics design [illegible] in the Laboratory's Communications and Public Information Department and an art teacher in the Pleasanton adult education program. Helen Robinson, division secretary for Planning and Development in Human Resources, gathered [illegible] for the program and assisted [illegible] in the day-to-day activities.

Says [illegible], "The primary goal of this program was to show that a partnership exists between science and English. Art serves science by depicting abstract and difficult scientific concepts [illegible]. [illegible] what [illegible] to be a professional artist in a [illegible] world."

[illegible]

[illegible]



If you want more information about the Laboratory's Science Education Center

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EDUCATION OUTREACH PROGRAMS

Lawrence Livermore National Laboratory

May 1989

Manuel Perry
Human Resources
Planning and Development

EDUCATIONAL PROGRAM PARTICIATION
PRE-COLLEGE SUMMARY TABLE
(K - 12)

ACTIVITIES	STUDENT PROGRAMS	FACULTY PROGRAMS	STD/FAC PROGRAMS
Advisory/Consultant	0	1	0
Career Fair	1	0	0
Collaborative Research	0	1	0
Conference	1	1	0
Other--Information Sharing	0	1	0
Other--Teacher Enrichment	0	1	0
School Year Work Experience	2	0	0
Skill Training	3	0	2
Student/Teacher Training	0	0	2
Summer Work Experience	2	0	1
Teacher Training	0	4	0
Teacher Training/Research	0	1	0
Tours/Speakers	1	0	2
Workshop	3	1	0
	13	11	7

GRAND TOTAL = 31

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Career Fair

TITLE: Career Days

EDUC GROUP (STUDENT): Elementary/High/College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Upon request various schools will have a career day. Various Laboratory departments will set up information booths on campus regarding careers. Chabot College Valley Campus sponsors an annual Career Day which LLNL employees have been participating in for the past 7 years.

ACTIVITY: Conference

TITLE: Expanding Your Horizons Science & Math Conference

EDUC GROUP (STUDENT): 6th-High School

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

A 1 day conference, held at Chabot College in Livermore. The Livermore conference is one of about 80 EYH conferences held across the country annually. Coordination is through the Math/Science Resource Center at Mills College in Oakland. The Center was founded in 1976 for the purpose of putting on these conferences. The purpose of the conference is to encourage junior high and senior high girls to continue taking math & science courses and to provide them with female role models in the scientific areas.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: School Year Work Experience

TITLE: Plant Engineering Experience Program (PEEP)

EDUC GROUP (STUDENT): High School

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

A high school work experience program for students 16 years of age until graduation. They work 15 hours per week during the school year and full time during the summer and holidays. Major emphasis is learning responsibility and commitment to what having a job means.

ACTIVITY: School Year Work Experience

TITLE: Student Technology Experience Program (STEP)

EDUC GROUP (STUDENT): High School/College

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The program offers local high school and college students meaningful work experience, and encourages them to continue their education in science, engineering or business. Participants must be full-time students and maintain a satisfactory academic standing. Participants can work up to 16 hours per week during the school year and 40 hours per week during the summer.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Skill Training

TITLE: Apprenticeship & Pre-Apprenticeship Program (AP)

EDUC GROUP (STUDENT): Apprenticeship

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

AP program supplies on-the-job training and classroom training leading to state certification as a journey-level craftsperson. Participants work full time in advanced technologies during their 3-4 year apprenticeship. At least 144 hours of related classroom instruction and approx. 2000 hours of productive work are included in the program. AP positions are published in the Lab's CURRENT EMPLOYMENT OPPORTUNITIES bulletin. Applicants must be 18 and have a high school diploma or (GED). Applicants are required to take a standard math and mechanical test.

ACTIVITY: Skill Training

TITLE: On-The-Job Training Program (OJT)

EDUC GROUP (STUDENT): Elementary/High/College

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

OJT program provides technical and clercial skills training to individuals who have limited marketable skills and are unemployed or underemployed. Successful completion of the training and the existence of an appropriate opening can lead to career employment at LLNL.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Skill Training

TITLE: Tutor Program

EDUC GROUP (STUDENT): 7th-College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The tutor program brings together Lab employees with students who want help in understanding math, science and computers. The service is voluntary and tutoring is done during non-work hours. Since 1977 more than 800 students have been matched with LLNL employees. In 1984 more than 200 students were tutored on a variety of technical topics. The care and encouragement Lab tutors show have often been cited by students as a prime factor in their decision to continue on in the math, science and computer fields.

ACTIVITY: Summer Work Experience

TITLE: DOE High School Student Supercomputing Honors Program

EDUC GROUP (STUDENT): High School

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The program offers the brightest high school students in the field of computational science hands-on experience with the world's fastest and most sophisticated computers. In addition, it introduces the students to Laboratory scientists -- experts in a variety of disciplines -- who share their computing experience with the students. Each student completes a programming project to demonstrate the capacities of the supercomputers. This hands-on experience provides an opportunity to solve problems in mathematics, physics and computer graphics.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Summer Work Experience

TITLE: High School Summer Program

EDUC GROUP (STUDENT): High School

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Program provides on-the-job work experience for 1 Granada High School student and 1 Livermore High School student. Gives students exposure to the LLNL environment and provides community involvement by the department.

ACTIVITY: Tour/Speaker

TITLE: Explorer Post Boy Scouts of America

EDUC GROUP (STUDENT): High School/College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The program was established to encourage young people to explore careers in science and engineering fields. Girls and boys, between the ages of 14 and 20, have the opportunity to interact with LLNL scientists and engineers and to attend lectures and tours. The main goal of the program is to have participants gain insight into careers through hands-on experience.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Workshop

TITLE: Art in Science

EDUC GROUP (STUDENT): K-12

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The purpose of the project is to have students understand the role of art in science, science history, and learn about Black contributors to the fields of science and technology. The workshop is designed to enhance students' art skills, teach graphic design, discuss careers of art in science, and learn about Black scientists and inventors.

ACTIVITY: Workshop

TITLE: Engineering & Science Career Day

EDUC GROUP (STUDENT): High School

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

M. E. held a one-day workshop. Mechanical engineers and scientists answered students' questions and gave overviews of their careers. They also explained how they became interested in science and technology, what high school and college courses are required, etc. The goals for the workshop were to encourage students to pursue careers in science and math and, because of the shortage of females with good math backgrounds, to encourage female high school students to keep taking math courses.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Workshop

TITLE: Science On Site (SOS)

EDUC GROUP (STUDENT): K-8

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

A workshop for the entire staff of an elementary or middle school. Held at the school, it is a special time for teachers and administrators to take "time out" together to analyze their science teaching techniques, attitudes and goals. The focus is on helping teachers. Workshop also covers the general goals of science education, including preparing young people for a modern technological world where science and computer literacy are becoming mandatory.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Advisory/Consultant

TITLE: Livermore Valley School District Science Advisory Council

EDUC GROUP (FACULTY): Advisory Committee

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The purpose of the council is to improve the quality of science education in the Livermore Valley elementary & secondary schools. The council is involved in long-range district planning, makes recommendations, provides technical advice and proposes and reviews ideas for science projects and programs.

ACTIVITY: Collaborative Research

TITLE: Green House Gases & Global Climate Change (CO2)

EDUC GROUP (FACULTY): High School/Middle School

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

A program to provide teachers nationwide with the support necessary to develop effective, multi-disciplinary instructional materials for addressing issues related to the problem of carbon dioxide build-up in the earth's atmosphere. By focussing on a problem of international concern, this program creates a setting in which the physical, life and social sciences are seen as relevant and beneficial to humanity. The program also inspires a valuable partnership between the nation's scientific and educational communities.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Conference

TITLE: Preparing for Tomorrow's Technological Needs

EDUC GROUP (FACULTY): Elementary/High/College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The conference was aimed at identifying creative solutions to the critical issue of the nation's ability to supply the technical workforce of the future. A total of 300 Bay Area educators and representatives from private industry and the Laboratory attended. As a result of the conference, LLNL staff have been asked to attend curriculum and school district advisory boards. The goal of the conference was to increase the interest of elementary, high school and college students in careers in science and technology so there will be no shortfall of manpower in these fields in the future.

ACTIVITY: Other-Information Sharing

TITLE: Electronic Educational Bulletin Board

EDUC GROUP (FACULTY): Elementary/High/College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Program was established to provide a national network to local teachers for science curriculum sharing and general information sharing, etc.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Other-Teacher Enrichment

TITLE: SEC Saturday Lecture Series

EDUC GROUP (FACULTY): K-12

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

This school year series is designed primarily for elementary thru high school teachers, to give them a chance to meet informally with leaders of the computer and science fields. This gives teachers an opportunity to experience some of the powerful ideas that they so often have read about, but have never had the chance to experience first hand. The base audience is teachers, but students in elementary thru high school can also find these lectures interesting and informative.

ACTIVITY: Teacher Training

TITLE: Hands-On Experimental Laboratory Program (HELP)

EDUC GROUP (FACULTY): K-8

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

HELP workshops provide hands-on experiments and projects that elementary and middle school teachers can adapt for their own classrooms. HELP workshops are conducted free of charge at the SEC. Academic credit is available through Cal State University, Hayward. Enrollment is limited to 12 teachers.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Teacher Training

TITLE: Helping Our Partners Enrich Science (HOPES)

EDUC GROUP (FACULTY): K-6

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

HOPES is a comprehensive teacher training program designed to help elementary school teachers gain confidence and support in the teaching of science.

ACTIVITY: Teacher Training

TITLE: Lawrence Livermore Elementary School Study of Nature (LESSON)

EDUC GROUP (FACULTY): K-8

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The goal of LESSON is to develop and maintain in students of a young age the potential for science study and to motivate them to embrace the study of science through high school and college. The Laboratory provides 2.5 week workshops for elementary/middle school teachers. The workshops demonstrate the "hands on" approach to teaching science and respond to teachers' questions in the areas of physics, chemistry, biology, electricity and magnetism. Materials for in-class and take-home experiments are provided.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Teacher Training

TITLE: Summer Science Institute (SSI)

EDUC GROUP (FACULTY): K-6

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

SSI helps teachers feel better about teaching their science classes. SSI includes lectures, experiments, lesson planning and field trips. Teachers also experiment with lessons they develop, by presenting them to summer school classes. Teachers who participate in SSI hold in-service training workshops, at their individual schools, to share what they learned over the summer.

ACTIVITY: Teacher Training/Research

TITLE: Caribbean Basin Program

EDUC GROUP (FACULTY): K-8

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The Lab does collaborative research and special projects that are mutually beneficial to the Laboratory , University of Puerto Rico and the University of the Virgin Islands. One project is the Laboratory's co-sponsorship with the Univ of the Virgin Islands and the Virgin Islands Dept of Education to conduct two LESSON workshops during the summer of FY88 to upgrade the level of elementary school science education in the public and private schools on the islands of St. Thomas and St. Croix.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Workshop

TITLE: M. E. Summer Engineering Institute Program

EDUC GROUP (FACULTY): High School/College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Community College and High School teachers participated in this program. Workshops are held on various technological subjects plus Laboratory tours are offered. Teachers are given materials to use in the classroom, plus copies of all lectures during the workshop. The goal is to stimulate students' interest in technology by giving drafting teachers up-to-date information. Because of the overwhelming state-wide response to this program, a proposal was made to the State, that the same type of workshop be held in Southern California. Hughes Aircraft was interested in administering this program in Southern California.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT/FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Skill Training

TITLE: Computer Learning Center

EDUC GROUP (STU/FAC): K-12

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Offers a wide range of classes, workshops and self-guided tutorials on the facility's IBM, Apple II and PLATO courseware. Prime goal is to help teachers and students overcome fears associated with using computers as well as to provide assistance. Tutorials cover topics such as LOGO, BASIC, typing, and other programs from the software library.

ACTIVITY: Skill Training

TITLE: Logo Classes

EDUC GROUP (STU/FAC): K-8

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Beginning, intermediate and advanced level Logo computer classes are offered to 3rd thru 8th grade students. Classes are 2 hours and are held before, during and after school. Logo classes vary from elementary programming to working with the fibonacci number series and fractals. Summer classes are offered to students as well as faculty.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT/FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Student/Teacher Training

TITLE: Fusion Energy Education Program

EDUC GROUP (STU/FAC): Elementary/High/College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The goal of this program is to provide material for integrating information about the fusion process and fusion technology for science education at all grade levels.

ACTIVITY: Student/Teacher Training

TITLE: Star Project

EDUC GROUP (STU/FAC): K-12

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Through the federal Star Schools program, students receive math, science and foreign language instruction via satellite. The Lab, California State University system, NASA and the California Institute of Technology joined together to write the state's $5.7 million grant proposal. Some $100 million in federal education funds will be awarded over the next five years. Currently, the Lab offers teacher training workshops and activities. With the inception of the Star Schools program, teacher training and workshops will be expanded more widely by state-wide broadcasting.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT/FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Summer Work Experience

TITLE: Summer Youth Employment Program (SYEP)

EDUC GROUP (STU/FAC): High School

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Plant Engineering works with the school district to employ disadvantaged and educationally handicapped students for the summer. The students have an on-site supervisor from the school district as well as close supervision by Laboratory personnel. Students are employed as gardeners, custodians and in clerical positions.

ACTIVITY: Tour/Speaker

TITLE: Livermore Computer Center - Computer Museum

EDUC GROUP (STU/FAC): Elementary/High/College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The museum offers a "hands-on" exhibit. Three videos - "A Calculated Growth", "Graphics" and a "Tour Through the Computer Center". Located at Almond Ave School in Pod F. Preferred group size is 20.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE PRE-COLLEGE STUDENT/FACULTY PROGRAMS
(K-12)

LISTED BY TYPE OF ACTIVITY
May 9, 1989

ACTIVITY: Tour/Speaker

TITLE: Speakers Bureau

EDUC GROUP (STU/FAC): Elementary/High/College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

EDUCATIONAL PROGRAM PARTICIPATION
UNDERGRADUATE SUMMARY TABLE
(COLLEGE/UNIVERSITY)

ACTIVITIES	STUDENT PROGRAMS	FACULTY PROGRAMS	STD/FAC PROGRAMS	
Advisory/Consultant	2	1	1	
Collaborative Research	0	1	0	
Conference	1	0	0	
Educational Development/Support		0	0	9
Other--Course Work	1	0	0	
School Year Work Experience	2	0	0	
Skill Training	0	4	2	
Summer Work Experience	1	0	0	
Tours/Speakers	0	0	2	
Workshop	0	0	1	
	7	6	15	

☛ GRAND TOTAL = 28

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Advisory/Consultant

TITLE: Arizona Navajo/Hopi Indian Project

EDUC GROUP (STUDENT): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The Dean of Engineering at Northern Arizona University requested assistance from Laboratory engineers in helping some 150 university engineering students install photovoltaic cells on the roofs of hogans at the Navajo/Hopi Indian reservations which would enable Indian students to have electric lights to study by at night. In addition, mechanical engineers and department heads are currently working with the Tribal Indian Council to develop a pre-engineering school on the Navajo reservation, with the goal of lowering the high drop-out rate of Indians students at the university. This is the first modernized study facility on an Indian reservation.

ACTIVITY: Advisory/Consultant

TITLE: Hispanic Engineering Education Support Program

EDUC GROUP (STUDENT): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Program provides Northern Arizona University Hispanic engineering students with support in three areas: academic, such as counseling, tutoring and mentoring; cultural, pairing each student with a Hispanic community support group in his/her hometown; and economic, under which NAU will contact industries in the student's hometown to arrange for part-time, summer or cooperative employment.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Conference

TITLE: National Association for Equal Opportunity (NAFEO)

EDUC GROUP (STUDENT): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

NAFEO sponsors annually a conference to network information that would be helpful in the development of opportunities for HBCU's. Curriculum development, technology exchange and research cooperation are among the areas of interest pursued by the universities. LLNL's involvement with NAFEO has generated applicants for summer and permanent career positions with the Lab. Federal, private industry and non-profit organizations market programs and their manpower needs as well as participate in workshops focusing on development issues.

ACTIVITY: Other-Course Work

TITLE: Undergraduate Summer Institute on Contemp Topics-App Physics

EDUC GROUP (STUDENT): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

DAS, LLNL and the Hertz Foundation offer appointments to outstanding undergraduate physics and engineering students . The curriculum consists of lectures and projects. The Summer Institute provides the participants a unique opportunity to develop an understanding of the basic principles and current state-of-the-art of several currently very active and exciting areas in Applied Physics. The students gain hands-on experimental, theoretical or computational physics experience by completing a small project.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: School Year Work Experience

TITLE: Co-Operative Education Program (CO-OP)

EDUC GROUP (STUDENT): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

CO-OP program provides college students with practical research experience while tney are in college. Students alternate semesters working full time at the Lab and working toward their degrees. The work experience supplements and reinforces academic training. Emphasis is on scientific and engineering disciplines.

ACTIVITY: School Year Work Experience

TITLE: Utah Valley Technical College Co-op

EDUC GROUP (STUDENT): Other-Vocational Technical College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Purpose of program is to provide hands-on experience in the mechanical engineering technology field for vocational/technical students. The Co-op students get 3 months of on-the-job training and 3 months of technical school training and then return to the Nuclear Test Operations Division for 3 more months of OJT for a total of 6 months hands-on experience. The goal of the program is to provide NTOD with a good recruiting resource.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Summer Work Experience

TITLE: Summer Employment Program (SEP)

EDUC GROUP (STUDENT): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

One of the goals of the program is to increase the representation of minorities, women, veterans and handicapped persons in specific science and engineering fields. The program also gives participants exposure to highly qualified scientists and engineers, as well as to the Lab's outstanding high-tech research facilities. Students and faculty are selected on the basis of their career objectives, interest and academic achievement. Most work assignments are in science and engineering. In the summer of 1987, the Summer Employement Program (SEP) became part of SSIP.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Advisory/Consultant

TITLE: Vocational Education Advisory Council

EDUC GROUP (FACULTY): Advisory Committee

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

The council meets during the academic year to discuss directions and plans for Livermore Valley Schools' vocational programs and for the Tri Valley ROC programs.

ACTIVITY: Collaborative Research

TITLE: Summer Institute for Faculty Program (SIF)

EDUC GROUP (FACULTY): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The purpose of the program is to enrich the research and education programs at colleges and universities with high enrollments of minorities, women and handicapped students. Candidates should be faculty members from these colleges and universities. Selections are made by matching the interests of faculty members with full time summer employment opportunities.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Skill Training

TITLE: Collaboration/Universities--Cytogenetic Studies

EDUC GROUP (FACULTY): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Environmental Science Div. is doing collaborative studies with Drs. Jenkins and Sanders from Cal State Univ at Long Beach. They are continuing to adapt and develop state-of-the-art methods for the detection of cytogenetic damage in selected aquatic organisms.

ACTIVITY: Skill Training

TITLE: Collaboration/Universities--E. Siciliano, Univ. of Texas

EDUC GROUP (FACULTY): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

A project in Biomed and in collaboration with the University of Texas is underway to better understand the molecular detail of mutagenesis in mammalian cells and the role of DNA repair in the production of genetic alterations of environmental agents.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Skill Training

TITLE: Collaboration/Universities--Organic Chemicals Studies

EDUC GROUP (FACULTY): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Environmental Science is working in cooperation with Dr. Pinder of Princeton Univ to determine the feasiblity of using optrodes to monitor changes in concentrations of organic compounds in different subsurface materials. Experiments are also being conducted in cooperation with Dr. Dunja Grbic-Galic of Stanford University, who has conducted considerable research on the metabolism of organic compounds by subsurface microbes.

ACTIVITY: Skill Training

TITLE: Collaboration/Universities--Southern Calif. Bight Studies

EDUC GROUP (FACULTY): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Environmental Science Div is participating in an interdisciplinary program to investigate the fate of energy-related by-products in the deep basins of the Southern California Bight.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT/FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Advisory/Consultant

TITLE: Technical Volunteers

EDUC GROUP (STU/FAC): Elementary/High/College

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

LLNL Technical Volunteers have offered their technical expertise to assist in promoting science education. They have served on curriculum advisory committees and have helped teachers develop computer training skills to assist them in their classrooms. Volunteers have also advised students with special projects, served as mentors to students with specific career interests and helped evaluate equipment to be purchased for science programs. Additionally, they have helped schools with problems in energy conservation, acoustics, emergency preparedness, communication and science fair judging.

ACTIVITY: Educational Development/Support

TITLE: HBCU--Collaboration

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The HBCU program at LLNL contributed to establishing the Alabama A&M University doctoral program in physics--one of two PhD programs in physics at HBCUs in the U.S. The Free-Electron Laser Research Project serves to develop AAMU research capabilities and provide state-of-the-art research and training for graduates at AAMU. Faculty are also employed at LLNL thru the Summer Institute for Faculty program. LLNL co-hosted, with AAMU, a conference on the LESSON Program developed at the Laboratory. The purpose was to acquaint institutions with the program and suggest techniques for seeking funding.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT/FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Educational Development/Support

TITLE: HBCU--Collaboration

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

Dense Plasma Research is being done at Atlanta University. AU and LLNL scientists continue to collaborate on the calculation of electron collision cross sections for ions of the oxygen iso-electronic sequence and study of other iso-electronic sequences. This project provides opportunities for graduate students and faculty members from AU to participate in fundamental physics research at LLNL. It also provides thesis projects for graduate students and expanded AU research in atomic related plasma physics.

ACTIVITY: Educational Development/Support

TITLE: HBCU--Collaboration

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

LLNL provided assistance to Fort Valley State College in the development of an electrical engineering curriculum component of Fort Valley's Energy Science Degree Program. Faculty and students are employed at LLNL for the summer thru the Summer Institute Faculty Program and the Summer Employment Program.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT/FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Educational Development/Support

TITLE: HBCU--Collaboration

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The Toroidal Plasma Research project supports Hampton University collaboration with the U.S. Dept of Energy San Francisco Operations Office and Princeton Univ. The objective is the investigation of transition between H and L modes in neutral beam heated ASDEX-type devetor discharges.

ACTIVITY: Educational Development/Support

TITLE: HBCU--Collaboration

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The LLNL field-geology program accepts annually approximately 14 students enrolled at Howard University to study the latest geologic techniques at NTS for 5 weeks. Howard University and LLNL have an agreement to collaborate on physics research in the field of magnetism. Objective is to enhance the graduate program in physics and to contribute to HU leadership in the field of magnetism. Two LLNL scientists have implemented this program and serve as adjunct faculty.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT/FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Educational Development/Support

TITLE: HBCU--Collaboration

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

In collaboration with LLNL Jackson State University has instituted a bachelor's degree program in hazardous materials management. This is the only program of its kind in the nation.

ACTIVITY: Educational Development/Support

TITLE: HBCU--Collaboration

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

Computer hardware and software have been loaned to Mississippi Valley State University to support their Solar Energy Research Project. In addition, a professional and faculty exchange program was also deployed to strengthen the research capabilities of MVSU.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT/FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Educational Development/Support

TITLE: HBCU--Collaboration

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

Through the HBCU the Laboratory provides funds and assistance to Southern University to perform research in "Subsoil Solute Transport Modeling". As a result of this research project, SU and LLNL has developed a bachelor's degree program in Hazardous Waste Materials Management. Southern Universities Director of Energy, Dr. Fathy Saleh is the contact person for this degree program.

ACTIVITY: Educational Development/Support

TITLE: Historically Black Colleges & Universities Program (HBCU)

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The primary goals of the HBCU program are to increase scientific and technical expertise at individual colleges and universities and to train black students who wish to become scientists or engineers. Currently, the program works with more than 15 different HBCUs on projects ranging from field geology to computer graphics to free-electron lasers. The HBCU has formal collaboration with 12 historical black colleges and universities.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT/FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Skill Training

TITLE: Collaboration/Universities--Analytical Cytology Program

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Analytical cytology is the focus of a joint program between Biomed and UCSF Medical School. It's a highly effective mechanism for promoting interactions between LLNL and our colleagues at UC Medical Center. The program awards "mini-grants" as seed funding for collaborative research projects between investigators at UCSF and LLNL; it provides post-doctoral and faculty fellowships that support investigators from UCSF on assignment to LLNL; and it faciltates joint LLNL/UCSF developments such as our state-of-the-art fluorescent image cytometer.

ACTIVITY: Skill Training

TITLE: Summer Research Participation Program (AWU)

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

AWU is a consortium of universities which has the overall objective of promoting and coordinating research and training on projects of a regional nature that require interuniversity cooperation. It promotes training and research on energy-related science and engineering in the western part of the US. DOE through AWU, provides support for education and training programs at numerous DOE-sponsored research sites. LLNL is one of the DOE sites open for research participation by AWU students and faculty. AWU students work on research projects on a one-on-one basis with LLNL scientists.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT/FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Tour/Speaker

TITLE: American Indian Society for Science & Engineering (AISES)

EDUC GROUP (STU/FAC): Community College/College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The purpose of the American Indian Program is to increase the number of American Indian employees at LLNL and to increase the number of American Indian students pursuing careers in science and engineering at the college level. LLNL provides a $1000 student award and hosts 3-day visits by faculty, students and faculty advisors.

ACTIVITY: Tour/Speaker

TITLE: Navajo Community College Program (NCC)

EDUC GROUP (STU/FAC): Community College

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

LLNL technologists make week-long visits to the Navajo Community College campus and assist the college faculty in teaching classes, evaluating curricula and evaluating equipment. Presentations are made to local high schools and junior high schools through arrangements made by the college.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE UNDERGRADUATE STUDENT/FACULTY PROGRAMS
(COLLEGE/UNIVERSITY)

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Workshop

TITLE: Senior Design

EDUC GROUP (STU/FAC): College/University

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

"Senior Design" is a class at Cal Poly which actively seeks industry participation to sponsor student projects (problems not hardware costs, etc.). In February 1986 the Beam & Fusion Engineering Div. decided to participate in the program sponsoring a total of three projects (paper studies) over a period of 9 months. Currently the Nuclear Test Engineering Division is in the midsts of coordinating a set of projects to be sponsored by both NTED and Beam & Fusion Engineering Division to be completed by December.

EDUCATIONAL PROGRAM PARTICIPATION
GRADUATE STUDENT/POST-DOC/FACULTY SUMMARY TABLE

ACTIVITIES	STUDENT PROGRAMS	FACULTY PROGRAMS	STD/FAC PROGRAMS
Other--Graduate Fellowship	1	0	0
Other--Work Experience	1	0	0
Skill Training	2	0	0
Summer Work Experience	1	0	0
	5	0	0

☛ **GRAND TOTAL = 5**

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE GRADUATE STUDENT/POST-DOC/FACULTY PROGRAMS

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Other-Graduate Fellowship

TITLE: Natl Phys Sci Consortium For Graduates Degrees-Min. & Women

EDUC GROUP (STUDENT): Other-Graduate Students

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The main purpose and goal of this program is to expand the pool of qualified women and minority PhD's in the physical sciences.

ACTIVITY: Other-Work Experience

TITLE: Post-College Appointment Program (PCA)

EDUC GROUP (STUDENT): College/University

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

PCA provides Laboratory-relevant work experience to individuals who have completed the academic requirements normally associated with professional career employment in science and engineering disciplines. Participants work full-time.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE GRADUATE STUDENT/POST-DOC/FACULTY PROGRAMS

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Skill Training

TITLE: Occupational Medicine Resident Training (field assignment)

EDUC GROUP (STUDENT): Post Doctoral

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

There is an on-going occupational medicine residency program based at UCSF. The residents are assigned (1 per quarter) to the Health Services Dept. and work under the direction of the faculty here. This resident continues to be paid by UCSF but receives practice experience onsite.

ACTIVITY: Skill Training

TITLE: Post-Doctoral Research Staff Members(Post-Doc)

EDUC GROUP (STUDENT): Post Doctoral

AFFIRMATIVE ACTION PROGRAM?: N

PROGRAM PURPOSE OR GOAL:

Recent PhD's or equivalents perform basic research assignments at LLNL which allows the individual an opportunity to acquire further scientific training and to develop professional maturity in independent research. The Lab currently has approximately 44 Post-Doc employees working in various scientific departments.

EDUCATIONAL OUTREACH PROGRAMS
ACTIVE GRADUATE STUDENT/POST-DOC/FACULTY PROGRAMS

LISTED BY TYPE OF ACTIVITY
May 8, 1989

ACTIVITY: Summer Work Experience

TITLE: Natl Consortium for Grad Degrees for Minorities in Eng. (GEM)

EDUC GROUP (STUDENT): Other-Graduate Students

AFFIRMATIVE ACTION PROGRAM?: Y

PROGRAM PURPOSE OR GOAL:

The purpose of this program is to provide opportunities for minority students to obtain a master's degree in engineering through a program of paid summer eningeering internship and financial aid.

STATEMENT OF DR. WILLIAM F. WILLIS

Dr. WILLIS. Thank you very much, Madam Chairman and Mr. Schiff, it is a distinct pleasure for me to be here on your panel. I congratulate you for what you are doing——

Ms. LLOYD. I think they want you to move your microphone.

Dr. WILLIS. Is that better? Okay.

I am happy to be here on this esteemed panel and I appreciate the honorary doctor to make me fit in with this group up here, my esteemed colleague.

Ms. LLOYD. Think nothing of it, we are just happy to accommodate you this morning. One of the many services we provide on this Subcommittee. [Laughter.]

Dr. WILLIS. Thank you very much.

We are happy to be here and talk about some of our experiences in this very important subject that you are addressing on your Subcommittee. We support education as a part of our mission in the valley. One of the primary things we do besides electricity and river control is working on the economy of the valley, working with our industries, and we would like to bring maybe a little different perspective to this panel today, based on our experience in working with our industries and our new entrepreneur businesses that are springing up, and addressing some of the concerns that they have working with the chambers and economic development people in seven states.

We find some terrible things were happening in the valley, started in the early 1980's as industry started to recover from the recession of that time. When they came back, they wanted to retool in some of the modern technologies so they could compete in a global economy. And what they found is they did not have the skilled work force to work with that they needed to change their technology and their processes. We found that in looking at our school systems and the output of them around the valley, we found that of course, as you well know, that our SAT and ACT scores are down from 20 years ago, we found that there is an 80 percent decline in certified and trained teachers teaching science and math in our schools, and most of our school systems are rural school systems in the valley. We found another disturbing thing to overcome that dearth of good qualified science and math teachers, that there is only about half of the number of science teachers being graduated in our major institutions and only about one-seventh of math teachers, as there was some 10 or 15 years ago, and that was a very disturbing statistic to us.

We also find that in our high schools in preparing our children to go on to either four-year schools or postsecondary schools to get a technical type degree to work, that about 40 percent of the kids coming out of the high schools only had a general education type degree, and about 20 percent were coming out with some vocational education type degree that was not geared to the type of industry that was out there today. And what was missing in both of these curriculums was science and math type backgrounds. We found that postsecondary schools, two-year colleges and community colleges were having to go to remedial courses to get them ready for the technical courses that industry was demanding today. And besides that, these kids were not able to go on to a four-year curriculum because the type of work they were getting at the two-year colleges did not prepare them to move on into the four-year curriculums, and particularly because of the problems of science and math. We had a terrible waste segment in our education system.

And that was impacting our ability to attract industry in the valley, it was impacting our ability to be globally competitive, not only in the valley, in the nation. So we could not stand back and not do anything. We are not educators and we do not have the high degree of science capabilities that are in the labs, but we thought we might could be integrators between industry, the postsecondary and secondary school systems and the laboratories where the science is available, to take some of the technology that is available today and make it applicable to help our students in our school systems catch up and provide the resource that our industries so desperately need today.

We started out down in Mississippi, the first place we started, because of the problem in the high schools around the area that industry had identified, that the science and math teachers were not certified to teach courses in nine counties around there. There was only a small percent that had certifications to teach what they were teaching. So we worked with a private foundation in Mississippi and the newspaper and the local school boards in the state and industry, to put together a program to help to bring teachers in from those school systems, so they could get their certificate to teach science and math, help upgrade their laboratories and their teaching equipment in their schools. We did that also with the University of Martin and nine counties around the University of Martin—University of Tennessee at Martin. And that program just really did what we thought it would do, it turned on the teachers which later turned on the kids. We had 109 teachers in Mississippi and 63 I believe at Martin, over at the University of Tennessee at Martin, and we were particularly pleased at Martin, not only what it did for the school systems and the test scores with the kids, it upgraded that tremendously, but three-quarters of all of the ones I believe in Tennessee at Martin got their certification to teach science and math and nearly three-quarters of them then went on to get their Masters degree in science. One of the participating teachers at Martin, we are very pleased to report, was the National Teacher of the Year. And the University of Tennessee at Martin, you know, has been designated as a math and science center of excellence and we believe that part of our program that we work with is one of the reasons why they were selected.

Another thing we are doing is we are considering how we could expand environmental education in science and math in the most effective way throughout our region to help motivate kids to be turned on to it by looking at the practical side of science and math, get turned on to it and then move on to higher echelons of those curriculums.

We have set up an environmental network, education network, among universities in our area, the southeast, we have 14 universities we are working with now and we hope to have 17 when we are finished, but we get about 500 teachers coming in during summer months and off months per year at each one of these centers, working on problem solving, curriculum development of how they can take problem solving back into the classroom. And we think that these materials focusing on the real problem solving and not on rote memorization helps students to get a more meaningful grasp of basic science and math, and they begin to get turned on to it. We are very pleased with that program, it has been a dozen years in existence and growing every year and we are very excited about what is happening as a result of that program.

It is also—we are very pleased that that program has been used as a national model by the Alliance for Environmental Education. It has about 35 organizations across the country that embrace that concept. Here in Chattanooga at the University, we have a water quality monitoring network where 35 teachers and some 110 students from 33 schools in the area are conducting field studies and this enhances the richness of their understanding of science and math through practical application, and again I think it turns them on more to that curriculum as a vocation for the future. In addition there are about 4,000 students from the region that have additional field work at our Land Between the Lakes Living Laboratory between Barkley and Lake Kentucky. Several of the participating teachers and students in these programs are winning national and regional awards as a result of it.

In working with industry in the region, we are finding two problems. As they are having to convert to new technologies, they are having to retrain their work force that they have in place. As you well know, the work force that we are going to depend on in the year 2000, most of those people are in the workplace today. Unfortunately, they missed an opportunity to get some development and education that I believe they wish they had now because the new jobs are demanding a type of understanding of cognitive skills in science and math that was not required some 10 or 15 or 20 years ago. So we are working with postsecondary schools to develop programs to bring back from industry people that need to be retrained, really to get some principles of technology, so they can be trained in new demanding type technologies that the world demands today.

Also we are working in one particular program we are proud of in Tupelo, Mississippi. It is a model program to line up two years of high school into two years of junior college or community college work to help bridge that transition into the technology world of today. It demands a lot more attention to science and math, it gets away from general education. Not only does it prepare the high school student to be more readily adaptable to the technology courses, laser technologies and all the computer based technologies of today, robotics and things that are required by the industries that are employing these two-year college graduates, but it also lines them up better to go on to four years of education if they choose to do that after two years in the postsecondary schools. That program down there is—we know the people, the community of Tupelo and Lee County that we work with, the industrial development people, the industry base that we work with down there have credited that program with the creation of some 2,600 new jobs in that area that they might not have been able to attract if they did not have that skilled work force.

Industries today are looking at areas that pay tremendous attention to the education sector in developing the skills that they want. You know very well, Madam Chairman, the impact and the amount of weight in the superconductor and supercollidor project that is given to local educational systems in that selection process. And that is something that we need to be more and more concerned about.

One very interesting program—I got very concerned a few years ago that the divergent and wide-spread opportunities that was becoming prevalent in the area between urban schools and rural schools. As you well know, and in your district, there are a lot of rural schools that do not have the opportunities from the tax base or other teacher base that maybe some of our better urban schools have. So we wanted to look to see what we could do to develop a model rural school system that could bring the modern technology to that school system and overcome the impediment of a tax base of being in a rural area or having the teacher or equipment capability to teach the kids on a level field, that other kids were getting in urban areas.

We worked up in Coalfield, Tennessee, and I know you know where that is up in Campbell County, and we are using the video laserdisc technology to teach students math and science that is cosponsored by the National School Board Association, Tennessee Department of Education and the local school boards. There are about 30 teachers now that have been through that program in two years and some 2,000 students, and we are having that program evaluated by Vanderbilt and they find that the kids in the school learn about 40 percent more quickly, they retain about 30 percent more than they have under the standard courses, methods of teaching in the area. And the most exciting part about it—that is great and we expected that to happen—but the thing that is exciting about it is they used to have a terrible discipline and drop-out problem in the school and that has almost gone away, because the kids have got excited about learning and they want to be there. Another program up at Tennessee's Alvin C. York Institute that we are working with. This is a school in another rural school system that could not hire a physics teacher, just could not get one to come there. We worked with Tennessee Tech and the Chamber of Commerce in that area and some business people to bring in the satellite course from Oklahoma State University on physics and we find that—we were concerned that they could not get the quality of education they needed through that, and a control program with a control class in other schools that had good science teachers, good physics teachers. We found out that this method will work and in fact I believe they scored about 23 percent better than the control group.

It is one thing to talk about how to get this technology that is available that is coming out of our laboratories and out of our research and educational research institutions to our kids. We have been working with the State of Tennessee this last year to try to take the fiber optics technology and help in that regard of transferring this teaching technology to schools. As you know, we have been putting a—we are involved right now with putting 850 miles of fiber optics cable across our high voltage transmission system for our own communication system, as well as leasing it to a communications company. We are working with the State now to see if we can take this technology and working with universities or laboratories or whomever the partners we can get, to try to take some of the exciting teaching capability and knowledge that we cannot other wise get, into some of these rural areas in larger rural school districts, through fiber optics, that we can get a wide band of possibilities of teaching and demonstration that we can take. I think that is very exciting and we are very pleased to work with the State of Tennessee to try to help make that happen.

I have given you a few examples of some of our partnerships. We are not a laboratory, but we are a demonstration agency that we see impediments to economic development in the area and we try to find the best technology and the best expertise and marry it up with a problem to help overcome that. And we see education as one of the—I guess it is one of the most serious things that we have got to deal with in the valley, to help ourselves compete in a global economy. We are doing anything we can to marry the technology with the kids and with industry. Partnerships are important. We find in the areas that we work, that when we get good partnerships with industry, the education community and the local government, we can make something happen.

And I think that is what you are talking about in your hearings today, as to how to take these partnerships and put them together and help our Nation. We find that I guess one of the biggest lessons that we have found out of all of this, are the kids, the students, that we have dealt with that can be turned on when they are given the stimulus. They get excited about it and they do tremendous things when they are given that kind of opportunity.

As I mentioned a minute ago, to bring these technologies that are available, an understanding of science from people who can really motivate like these gentlemen here and the people in the laboratories, they can really motivate and turn our kids on. We have got the technology capability today to take that, either bring the kids to the laboratories or take the laboratories to the kids, and we should find ways to do that and I would hope that your Committee keeps turning up the heat all the time to find better ways to do that. You are on to something very important and we at TVA would like to work with you in any way we can in demonstration projects to help advocate that and move it on to higher levels.

Thank you very much.

[The prepared statement of Dr. Willis follows:]

REMARKS BY W. F. WILLIS, CHIEF OPERATING OFFICER
TENNESSEE VALLEY AUTHORITY
BEFORE THE HOUSE SUBCOMMITTEE ON ENERGY RESEARCH AND DEVELOPMENT
COMMITTEE ON SCIENCE, SPACE, AND TECHNOLOGY
MAY 15, 1989 CHATTANOOGA, TENNESSEE

TVA is probably best known as one of America's largest producers of electrical energy. We also manage the Nation's fifth largest river system, and we carry out a wide range of other resource development responsibilities for our seven-State region and the Nation.

TVA is vitally interested in helping to improve the welfare and quality of life of the people of the region. Over the years, we have become strong supporters and partners in the work of educational institutions. We recognize that solid programs in math and science are essential if the region is to maintain a strong and productive economy.

Unfortunately, however, the condition of math and science education in the region is no better than in the rest of the country, and in many cases it is much worse. Student SAT and ACT scores are significantly lower than they were 20 years ago, and in the last ten years we have seen an 80 percent decline in the number of trained and certified science teachers in secondary schools across the Nation.

According to a study by the Cooperative Institutional Research Program, our Nation's colleges are attracting only half as many science majors and one seventh as many math majors as they did in 1966. In the meantime, the number of students entering business programs has more than doubled, and the very brightest are going on to law school. As one professional engineering journal recently noted, however, we cannot sue our Nation to greatness.

Math and science are the building blocks of today's technical society. Unfortunately, the students who graduate from high school are often poorly equipped to tackle the more technical jobs that society has to offer. Forty percent of the high school students who take a general education curriculum are relegated to the lowest rungs of jobs in our economy. And when they seek better jobs, they typically need years of remedial education to prepare them for advanced study. Another 20 percent of the students participate in minimal or outdated vocational training programs, and these students, too, are typically ill-prepared for either truly technical jobs or for further education.

In the early 1980s, as a result of concerns about the quality of education in rural parts of the Tennessee Valley, we sponsored a joint project with the CREATE Foundation and Itawamba Community College in northeast Mississippi. Our studies had shown that among the rural schools in a five-county area, few of the instructors were actually certified to teach, and the SAT scores were well below the national average. Another nine-county study, conducted in west Tennessee with the support of the University of Tennessee at Martin and the Tennessee Department of Education, produced similar results.

As a result of these studies, we helped develop programs to encourage the teachers to upgrade their skills. One hundred and nine teachers from 14 area high schools participated in the Mississippi program, and 63 teachers participated in the Tennessee program. The results exceeded all our expectations.

In the Tennessee program, for example, almost all of the participating teachers became certified, and nearly three quarters of them went on to earn master of science degrees. One of the participating teachers was even named national Teacher of the Year. Moreover, when the University of Tennessee at Martin was designated as a Math and Science Center of Excellence, our program was recognized as one of the factors considered in the designation.

TVA has also developed an environmental education program that has proven to be highly effective in helping instructors teach math and science. The secret of the program's success is a network of environmental education centers located at colleges and universities throughout the region. Fourteen centers have been established over the last 12 years. Eventually, we hope to have 17 centers in all. Each of the centers conducts training workshops for approximately 500 teachers a year. They also develop and disseminate educational materials, help communities solve local environmental problems, and conduct research on the practical aspects of environmental education.

The supplementary educational materials are intended to be used as practical problem-solving tools for general math and science courses. Because the materials focus on problem solving, not rote memorization, they help students get a more meaningful grasp of basic math and science skills. As a result, students understand the principles better and retain the information longer.

The network has been so successful that it is being used as a model for a national network developed by the Alliance for Environmental Education. The Alliance is a national association of 35 organizations, including such diverse groups as the American Gas Association, the Boy Scouts and Girl Scouts of America, Edison Electric Institute, the Issac Walton League, the National Audubon Society, the National Education Association, and the Soil Conservation Society of America.

In another program conducted through the University of Tennessee at Chattanooga, TVA is using high school students to operate a water quality monitoring network. As of last December, 35 teachers and 110 students from 33 schools throughout the Valley had conducted field studies, and over 4,000 students had received additional instruction in water resources management. Workshops and a summer "water camp" at TVA's Land Between the Lakes are an integral part of the program. Several teachers and students have won regional and national awards through their participation in this program.

To help students acquire better technical job skills training, TVA has set up programs in several locations throughout the Valley. In each location we work with local industries, communities leaders, high schools, community colleges, and universities to provide technical training for high school and community college students. By integrating the last two years of high school with the first two years of college, we have created four-year technical training programs that meet the needs of students and local industry.

The first program was established in Tupelo, Mississippi, in 1981. It has since become a national model for career development. It has helped create more than 2,600 jobs in the Tupelo area, and it helps explain why Tupelo added more than 2 million square feet of commercial and industrial floor space during the past two years.

Many of our programs take advantage of sophisticated modern technology. In Coalfield, Tennessee, for example, we have developed a futuristic instructional laboratory using video laserdisc technology to teach students math and science. Video laserdiscs have been used for years in training airplane pilots, but have seldom been used in high schools or colleges. The video laserdisc is similar to the compact disc used in the music industry, except that it has video and software components. The teacher operates the laserdisc by remote control and uses it to supplement instruction and to guide classroom discussion.

The program is cosponsored by the National School Board Association, the State Department of Education, and local boards of education. Since 1985, 30 teachers and over 2,000 students have participated in the program. The results show that students learn 40 percent more quickly and retain 30 percent more information than they do under traditional instructional methods. Classroom behavior has also improved, and the student dropout rate has declined sharply. The lessons learned through this program are also being applied in other areas in the Tennessee Valley.

In another project, conducted jointly with Tennessee Technological University, the local Chamber of Commerce, and Oklahoma State University, students at the Alvin C. York Institute in Jamestown, Tennessee, are taking physics classes beamed via satellite from Oklahoma State University. The classes are interactive, and students talk to the instructor at Oklahoma State through a telephone. Tennessee Tech's evaluation of the program showed that the students' physics scores were 23 percent higher than those of a control group.

We are also working with the State of Tennessee on the feasibility of using fiber optics for telecommunications between high schools and universities. We are already stringing fiber optic cables on some of our transmission towers for the joint use of TVA and a long-distance telephone company. Similar fiber optic lines could be used by high schools and universities for interactive television classes in which students at several locations could talk with one another and with the instructor.

These are examples of TVA's partnerships in education across the region. The success of these programs is in large measure the result of cooperative efforts between education, government, business, and industry. We have shown that these partnerships can work. They have become a permanent part of our education system in the Tennessee Valley, and they are being applied elsewhere in the Nation as well.

One of the most important lessons we have learned through our education programs is that students today can be turned on to math and science if they are given the right stimulus. High-tech learning through computers, video laserdiscs, and satellite telecommunications is exciting to them. So is hands-on practical problem solving, which is offered through our environmental education network centers.

We have a wealth of educational resources in Oak Ridge National Laboratory, Tennessee's Chairs of Excellence, and the many research centers scattered throughout the Valley. Scientists at these centers are working on the fundamental problems of our time in high intensity environments that can trigger the imaginations of even the most jaded students. If we truly want to motivate our students toward math and science careers, we should allow them access to these resources.

The technologies that TVA and others across the Nation are developing can bring these resources into the classroom. To take these technologies beyond the demonstration stage, however, and make them national in scope, will require the cooperative effort of education, government, business, and industry--working in partnership for the good of America's future. If we hope to have a strong and prosperous future, we must begin overhauling our math and science teaching programs today, because today's students are America's future.

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Ms. **Lloyd**. Thank you very much, Bill. I am not only delighted to have representatives of our three national labs here, but I am also delighted that this gave us an opportunity for you to tell the story of what TVA is doing. It is rewarding for me to know that you are aware of the need to improve the work force and the quality of life here in the valley. So it is a great story that you have told and I appreciate that as well.

As you were giving your testimony, it occurred to me that what we are really talking about here in science and engineering education and technology transfer, is improving the quality of life and the opportunities for all Americans, which is our ultimate goal that we are working toward. But also, it seems to me that we are redefining not only the mission of education but our methods and our purpose of education as well, because there are so many—education has become more of an ongoing process than ever before. Would you agree?

Dr. **Willis**. Yes.

Ms. **Lloyd**. That is what we are having to work with. As we also look at the national laboratories, and we are certainly aware that they are national treasures, but I think there will be a greater awareness across our country of really what goes on in a national laboratory, what a national laboratory means to our country, that it is the great treasure-house of our country and if we do create new wealth, from a large part it will come from what goes on at our national laboratories.

In this light, would you gentlemen from the national laboratories comment on the fact that you will ultimately become regional centers to provide quality educational programs, as we redefine the role of the laboratories? Is there any way that you can collaborate or maybe divide responsibilities, that there is not an overlap, and ultimately working together as institutions of higher learning.

Dr. **Trivelpiece**. The microphone has been passed to me.

Ms. **Lloyd**. Well I am sure you know how to hand it down too.

Dr. **Trivelpiece**. There was a period in the history of the DOE laboratories, AEC laboratories, in which I think probably you could characterize their attitude toward the outside world as somewhat of insularity, if being somewhat isolated, almost hostily so in some cases. That period I think began to change somewhere in the early 1970s. While I was at DOE I tried to make the case with the laboratory directors during the various meetings that we had that that was no longer a suitable approach, that the pattern of the past was really not the proper pattern for the future, that in fact the laboratories themselves could not just simply say well okay, we have changed our attitude. We are now going to sit and wait for universities and industry to come to us. I said you have to take the initiative and go out and make contact with them. I thought that was true seven or eight years ago, I think it is still true today. To the extent that as a laboratory director I can cause that to happen, I will try to do so.

And the answer to your question after that long involved prelude is yes, they can; yes, they should and I believe that we can do more in trying to take the opportunity to make contact with institutions such as TVA and through universities and through high schools to expand into the educational arena. It is not a very expensive thing to do, it does take a little time, but the benefits both to the institution and to the nation are quite large.

I think some of the other countries do this as well, and I have noticed with some interest how Academician Velikhov in the Soviet Union has used the Kurchatov Institute and some of its resources to try to provide summer camps where students learn about computers and how to take advantage of them. This perhaps might upset some people in the United States that they are using computers over there, but they have made a serious effort to go after this and use their facilities to the benefit of their young people and I think we should do no less.

Ms. LLOYD. I am going to ask—I am going to put one question in with this as we pass the microphone down and then I am going to turn the microphone over to Congressman Schiff, but as each one of you make your replies, let me ask you one other thing. If you had additional money, where would you spend it; precollege, teacher training? Put that in your minds as the microphone goes down.

Dr. TRIVELPIECE. Can I add on to that then?

Ms. LLOYD. You certainly may, that is the reason I asked it now.

Dr. TRIVELPIECE. The thing that has concerned me, and I am a member of the Government, University, Industry Research Roundtable for the Academy of Sciences and just recently accepted the chairmanship of the Sciences Education Board replacing Shirley Hill next January. That has caused me to think about some of these things in ways that perhaps not everyone has. And what has troubled me is not so much that we are losing students at the seventh or eighth grade or ninth or tenth grade, what troubles me is we are losing them at the third and fourth year of life. You know, what happens to this absolute natural curiosity that children have when they are three and four years old, and then by the time you sample them again the third and fourth year of school, you discover that they not only are no longer very curious about some of these things, but in fact they have some rather well established degree of hostility toward science and technology. If you lose them then, it is just as bad as losing them in high school or junior high or wherever.

So if there are possibilities where the laboratories could begin to get involved even down at younger ages, in the grammar school and perhaps even try to establish community programs that explain to parents and thereby make it possible for preschoolers to have some awarenesses, that would be useful. That is not something where money is involved, but I wanted to add it.

Now more specifically to answer your question with regard to money, I think that just simply scholarships and fellowships, competitive throughout the United States, for the Department of Energy, much as those that were available through the Division of Nuclear Education and Training in the past, would be outstanding. This laboratory, if it had them assigned to it, would certainly take advantage of it or would be pleased to compete for the students who are granted them on a national basis. I do not care how it is done, I just think it ought to be done, whether it is national or local or subdivided.

Ms. LLOYD. Very good. Dr. Springer.

Dr. **Springer**. As to operating as regional centers, I certainly endorse that; not to the point where they do that exclusively and I do not think you had that in mind. For example, the way we operate and have for some time at the university level, is that the people that come to Argonne, and I think it is typical, those that come to the laboratory from the midwest certainly predominate but they come——

Ms. **Lloyd**. I think I really had reference to certainly you cannot cover all the disciplines at Argonne.

Dr. **Springer**. That is right.

Ms. **Lloyd**. As you look at expanding the roles of the laboratories, I wanted your opinion of maybe dividing up some of the disciplines.

Dr. **Springer**. Well that is the reason that I think we cannot become exclusively regional. That is there are people from Chicago that will want something that we do not have, there are people from Tennessee and Florida and California that want things that they can't get there. So we certainly need to concentrate, and I think that naturally happens, that we provide—we are a resource for the region but we also have to be, because of the varied nature of the lab as you say, a resource for the whole country.

The other sense in which we are a regional center is in a more general sense, that is not providing highly technical science education for someone interested in science, but general support for science education and also something we do not do a lot of and that is the general question now of science literacy. I think we can do a good deal more than that. That would be certainly on a regional basis—than we do now. The programs that have begun more recently with teachers certainly are a step in that direction, but I think we have a natural resource to help on the science literacy in that we do things that are exciting and get a lot of attention. Everybody who reads the newspaper finds out about some of the things that go on in the national labs and we have that natural mechanism to get people's attention and use it to talk about basic science literacy issues.

As far as what we would do with additional funds, the priorities that we have submitted to the Department of Energy say that we would put additional funds into precollege programs. I mentioned that we are close to the City of Chicago and have as a very high priority to develop a strong network of support for science teachers in that region. We would also put as a high priority to continue the development of the undergraduate program which allows people to come to the labs during the semester. This is the science analog of off-campus and semester abroad programs that universities have had for a long time. One of the main reasons I think that is important is that it is not just a lab activity, it is a partnership with the university community where these kinds of programs would be recognized by the university and the college as an integral part of a curriculum.

And then finally, I think it is also important that we provide opportunities for people to come, particularly for graduate student research, and to use the facilities of the lab where such facilities are not available in their universities. Those would be my three priorities.

Ms. Lloyd. Thank you. Dr. Perry.

Dr. Perry. When it comes to the regional centers, I believe very strongly in a regional center concept, primarily from the standpoint of the ability to be very effective and very focused regarding certain types of programs connected with follow-up. At the national laboratory we have the resources to assist in teaching, but at the same time we have sort of a responsibility to follow-up as part of that teaching. to bring an individual in where in fact there is little connection or at least ongoing connection, there is a tendency to send the ship back out to sea, but without the ability to continue to have the resources available.

So I believe primarily we should have regional—and I am talking regional not within 45 miles or 50 miles, but it can be within regions of states from the standpoint of how that national laboratory is located.

From the standpoint of dollars, I would see that ours would be one of continuing along the main thrust we have had for a number of years. We have to increase the pipeline, and that one is one of K through 8 with a high priority toward those type of programs of students as well as teachers. And in addition to that, it would be one of looking at the disciplines for which we provide instruction. Science, as in mathematics, we have quite a bit of course work, quite a bit of involvement in those areas. But I notice as part of your responsibility there is the issue of technology. Can you name one educational technology program targeted towards K through 8 that is pretty much effective across the nation? There are very few. And at the same time we have the scientists who may think of the idea, the engineer who may design it, 60 percent of our staff are technical support staff, and if you crank the numbers, we are running out of support staff as quickly as we are running out of scientists and engineers and we had better pay attention to how we are bringing along the whole student body of a school system to meet our future science and technology needs. And so we would use those monies targeted towards pipeline but across educational spectra.

Ms. Lloyd. Thank you, Dr. Perry.

Bill, what is your insight on this, how could there be greater interface between TVA and the labs?

Dr. Willis. Well as I mentioned awhile ago, one of the things we find that the kids get turned on to is some of the new technology for learning. As you well know, reading is the least effective way to learn and retain, hearing is second, seeing is third and doing, putting hands on is the most effective way. Some of the new technology that has come available in the last two or three years with the interactive video laserdisc, technology for teaching can expand the learning process ten-fold very easily and retention rate is great.

The thing that I would like to see is more marriages between school systems and universities where they develop the curriculum, provide the software for the interactive video laserdisc stuff in science and math, that is the most appropriate and exciting terms that these exciting scientists can talk about and at the same time some of the new technology in teaching married with that. If they can do that in the laboratories, provide that sort of help in developing that software to go with the new video interactive laserdisc type equipment, teachers can get turned on and expand and extrapolate their abilities many-fold times over. That is where I would like to see the help because these people have the technology, they have the know-how to do it and they have the excited people to tell the story, they can motivate and provide the technology at the same time. That is where I would like to see the attention put.

Ms. LLOYD. Thank you a lot. Mr. Schiff.

Mr. SCHIFF. Thank you, Madam Chair.

Gentlemen, there are two things; first, in the discussions we have been having now obviously on the role of the national labs and TVA, and really what we are talking about is centers' expert facilities contributing to education. Do you now have—this is a beginner's question I know because I just got to Congress—are you funded now for any such programs or is everything you are doing out of—taken out of your resources at least nominally line itemed for other purposes?

Dr. TRIVELPIECE. To some extent that is probably a question that would be better addressed to Toni Joseph since those funds the Department of Energy has that are dedicated toward this purpose come through her office, but yes, there are funds that are distributed in that. I think there could be more and I know one of the activities that we had talked about in the past was the idea of trying to have some sort of a year-round operation that quite frequently students come to the laboratories for the summer. In order for them to be there year-round, that would require some kind of housing facilities or dormitories or the like. This was considered a couple of years ago and as I recall there was an attempt to use third-party financing, but the third-party financing had some difficulties with the Office of Management and Budget because they regarded any third-party financing as an absolute commitment of the government even though it appeared that it had a pay-back feature built into it. And I do not quite know what the status of that is at the moment, but that would be one.

But it is a combination—I mean the direct answer to your direct question is it is a combination. There are some funds provided through the Department which are directly earmarked as educational funds, and then there are others which are in effect done on the margin and through volunteer activities at the laboratory.

Mr. SCHIFF. The others are welcome to answer or not answer. I think you have given sort of a general answer, Dr. Trivelpiece.

If any of you would like to answer, please do so.

Dr. PERRY. Mine is a little bit different. One of the issues I raised was the issue of sustained funding. A number of the programs that we offer, in fact the majority of the programs that we offer, are funded by the laboratory from the standpoint of however it takes to get the dollars, we will end up scraping up the dollars to get it done, if it is worth doing.

There is the need for additional funding if we are going to start moving toward regional centers, and especially duplicating or transferring these type programs in regional areas. At the present time, we may have some very good programs, but very limited in the dollars we can scrape together to move and duplicate those programs in a very sort of expeditious way.

Mr. **Schiff**. Let me ask on one other subject. There has been mention at least once if not a couple of times on the question of the number of certified science teachers now in the school system, and how that is particularly difficult in more rural areas for the school districts to provide. This is certainly not an original idea with me but it is one that I find very attractive. I would like to know if there is a possibility in your minds of appropriate staff members teaching courses in the public schools, say for example a physicist teaching one physics course in a high school during one semester. I obviously see two obstacles, one is that physicist is employed to do other things and would that staff member have the time to teach even one high school course. And I see a second problem with the certification of being a teacher. We are talking about certification in science, but I wonder if the educational system would permit someone who is not certified as a teacher to come in and teach even one course in their expertise.

I wonder if you have any thoughts on that, if that is being attempted or if you think those obstacles would be too great or could be surmounted. Whoever would like to start.

Dr. **Perry**. I know in our area the obstacles—the walls are not high enough that we cannot sort of scale over them, I believe the crisis is of such a nature. There are systems in the State of California where we can go for the emergency credential and we have people in systems in the State of California where in fact that strategy is being used. I would think if we were to think creatively with a large number of our employees now reaching the retirement stage and if we look at the termination rate and retirement rate as they're retiring earlier, there is a vast reservoir of top scientific talent coupled with educational systems where we can be creative around that credential, where we can tap into a pool that to date has not been tapped into, the retired scientific teacher for classroom teaching.

Mr. **Schiff**. But to do that full time—excuse me one second, Dr. Perry—under the present system they would pretty well have to go back and become certified teachers, would they not?

Dr. **Perry**. Yes, but not full time certified, you can go with emergency credential and by taking just a few courses, which the school districts working with the community college will authorize in fact to have the person end up with the credential, thereby being available to teach a semester class, to teach a weekly class. But that is an avenue I think worthy of pursuing.

Dr. **Springer**. The sort of thing you are talking about does happen in our neighborhood but on a very, very limited basis and on a highly individual basis. That is, there are a few individuals that in one way or another get connected to a school and interested in a school and they volunteer to do some—I do not think they teach full courses, they typically supplement in one way or another.

My feeling is from talking to the staff that to try to do that with research staff on any sort of a large or systematic basis would not work. That is, they do find the demands on their time to continue their research are the prime thing and they would take most of their time.

The other thing is that it takes a fairly rare individual to be able on the one hand to do advanced research and then to turn around and talk in terms that are understandable to someone who is 10 years old or 12 or 14. It takes a fairly rare combination of talents there I think.

Dr. **Trivelpiece**. My colleagues have covered this fairly well. I think that I would only add one thought and that is what is the harm that could come to students by being taught by a full time physicist, chemist or mathematician. I do not understand the apprehension or fear that school boards and school districts have with respect to allowing this as a possibility. That mystifies me. The worst that could happen is the kids might learn something.

Dr. **Willis**. In the two or three programs that we have worked with school districts on the certification problem, we have run into the same thing. We thought we could get some help from retired scientists and engineers and we ran into the same problem. It seems like the best answer is to use the scientists and engineers as motivators and really try to upgrade the skills of the teachers that are out there now, to bringing them back and they could come into laboratory centers like this and work with the laboratory and get their certification very quickly. They can usually do this in a couple of summers. That is the most rapid route to the remedial problem. One of the larger problems we have is getting students to involve themselves in science teaching programs and math teaching programs in the universities now. It has fallen off tremendously over the last number of years and we have a major concern there. That is where a program like the laboratories have to having the teachers to work part time with the laboratory and teach, to keep them motivated to stay in education, allow them to have a part time job with a laboratory or the scientific community so they can earn the esteem and remuneration from doing that and at the same time stay motivated to stay in teaching.

I think that is an area we have got to find a formula of how to keep our bright children interested in becoming teachers and staying in that profession once they get into it. That is part of the formula that we really have not given a lot of attention to. I do see the laboratories doing more lately of bringing the teachers in in the summer and giving them some summer employment, but that is a terrible problem we have in the country and we need to put more attention on it.

Mr. **Schiff**. One last thing, what about a more limited approach, and that is for example, as I said I am a lawyer—I believe I said it—by training and profession, and I used to go into the public high schools fairly frequently to give one or two lectures on my field of expertise in terms of criminal prosecution. And I did not teach the course, I did not represent that I was an educator because I am certainly not, but I at least felt I made a contribution by at least being before a class for an hour or two to tell them about what I did every day, which with respect to the teachers, they did not. I wonder if there are ongoing programs which at least do that much where perhaps a physicist by way of example, it is certainly not meant to be limited, could speak for an hour or two in a high school physics class. Are those ongoing ideas right now of any great dimension and moment, because in my area I am not aware that with Sandia National Laboratory and Los Alamos National Laboratory in our backyards, I am just not aware that their professional people are in our school system very often at all.

Dr. **Perry**. I believe your national laboratories like ours are doing what you just described. There are a lot of people who are in the classrooms every day. The way we address the question you just raised was from the perspective of those who are certified to be teachers on a semester or classroom basis. From the standpoint of motivators to go into the classrooms, that is going on daily. I mean we will have, on a yearly basis, hundreds of people from I know our organization, and I am well aware from Sandia and from Los Alamos similar type programs. But if you think about it, and especially from the standpoint of the national laboratories, we have a tremendous percent of total scientific talent in our national laboratories, located in those facilities. And if you compound that with the fact we have a tremendous number of minorities and women in those national laboratories, but when was the last time you have ever seen a Hispanic scientist on television, in a magazine? From the standpoint of role models, and if we are talking about the demographics shifting with more women and more minorities, as part of that mix, how do we leverage those valuable resources we have in our national labs, who are female and minorities, to get into those classrooms where they can be not only teachers in the way of content, but role models from the standpoint of what are possibilities for all students.

Dr. **Springer**. In our area certainly there are individuals going for short periods of time in the way that you describe into the classrooms. I do not personally have a good sense of the extent to which that happens. The main thing I would like to say is that I am looking forward to what I think will be one of the main benefits of the teacher program that the Department of Energy has just initiated, is to create more of this. That is, the teacher program will bring teachers to the laboratories for periods during the summer and these appointments might be repeated once or twice, and as a result of that I think a lot of teachers are going to make contact with individual staff scientists and develop personal relationships that they can then call on, the kind of thing that you describe, without having a formal program, without having to come through the lab director or the Division of Educational Programs, they will have a friend that they can call on. And I think this will multiply significantly and it is certainly a desirable thing to happen.

Mr. **Schiff**. Let me just conclude by saying that I have a very strong belief about government, which I brought with me to my present position, that we are all in this together. All of us here at these two tables, for example, are all paid by the taxpayers. There are different funding routes, but ultimately the same taxpayers pay us to do the same things. And I realize everyone has primary responsibilities and I do not mean to take away from that, but to the extent possible, I just want to say I applaud the idea of personnel from the national labs going into the school system, of personnel from the school system, the educators, being admitted to the national labs, and anything in which we share this knowledge and this talent pool that has been built up through the contributions of the very same taxpayers.

I would like to thank you gentlemen very much for answering my questions. Thank you, Madam Chair.

Ms. Lloyd. Thank you very much, Mr. Schiff. And our panelists, we appreciate your input and we will be submitting questions in writing that we did not have time to ask you. We would like you to respond and that will be included in the record. Thank you very much.

We are going to have panel two before we break for lunch and then after lunch we will resume our hearings with panels three, four and five. Our next panel includes Ms. Marjorie Bardeen, Program Director, Friends of Fermilab; Dr. Jon Veigel, President of Oak Ridge Associated Universities; Dr. Lee Riedinger, Director of the University of Tennessee Science Alliance. Our next panelists are friends of the Subcommittee and we appreciate your great help today as well.

If you would try to hold your oral testimony to around ten minutes and your entire statement will be made, without objection, in its entirety part of the record.

Please proceed, Ms. Bardeen.

Panel 2

STATEMENTS OF MARJORIE G. BARDEEN, PROGRAM DIRECTOR, FRIENDS OF FERMILAB; DR. JON M. VEIGEL, PRESIDENT, OAK RIDGE ASSOCIATED UNIVERSITIES; AND DR. LEE L. RIEDINGER, DIRECTOR, THE SCIENCE ALLIANCE

Ms. Bardeen. Chairman Lloyd and Mr. Schiff, thank you very much for having us come all the way from Illinois to share some of our experiences with you in science education.

I think you have heard an awful lot about what is going on at laboratories in a general way, so what I would like to do is focus on two programs that we have at the Laboratory and look at how we designed those programs, how we determined the audience and the goals of the programs and then also look at how we measure their effectiveness.

The Summer Institute for Science and Mathematics Teachers is a high school program for 60 teachers who spend four weeks at the Laboratory in the summer. They spend half of their time with research scientists in seminars and they spend half of their time in the high school laboratory setting with master teachers. There are four follow-up sessions and the teachers receive both a stipend and graduate credit for their work.

Before we began this program, we sought the advice of teachers, university professors and businessmen. When we spoke with them about what role the laboratory could play in our area in science education, they recommended that we focus on average teachers. They felt this was an area where we could reach a wide range of students and at the same time make a significant change in the quality of the education that those students received. Then they recommended for us some goals for our particular summer program.

First of all, they thought we should target lively and successful teaching strategies for existing materials. By that, they meant looking at computer applications, at laboratory and hands-on demonstrations and at problem solving. They wanted us to enhance the teachers' background in their basic subject area, but at the same time expose them to new ideas in scientific research. And finally, they wanted us to show the connection between science, society and technology. So so that teachers who come to Fermilab to spend four weeks in the summer are able to take a story like cold fusion, bring it into their classroom. They are not intimidated, they are very comfortable with letting this story unfold, not so much from the point of view of telling the students of the technical details of cold fusion, but in exposing it as a story of how science is done. They can certainly have learned a lot of things about validation of scientific experiments, about publication, et cetera, that help them understand how science is really done as opposed to perhaps how science is often taught in the high school classroom.

Well, how do we do with a program like this, what is our success rate. We actually have four ways of measuring the success of the programs, and in fact at the end of each year we publish a report. First of all, of course we ask the individuals how they felt the four week program went. We give them an opportunity to evaluate our effectiveness in achieving the goals and also comment on various staff members. We follow up a year later by asking them what they were able to use in their classroom from the program. Did in fact the materials that we present to them work with students in the high school classroom setting. And finally, we do talk to the participants three or four years later to find out if, as a result of our program, they have been sharing materials with other teachers, have they gotten involved in professional organizations, are they doing in-service programs in their area so that in fact the impact of the program is broad and not just limited to 60 participants.

Although we do not formally solicit input from department chairmen and principals and superintendents, we get a lot of anecdotal information back from them. This information on the Summer Institute indicates to us that it is a smashing success, and in fact one of the reasons it is a success is because it is not business as usual. When teachers come to Fermilab, they come to a world class research institution and they have an opportunity to meet scientists like Leon Lederman and they have a chance to go home and tell their students what a wonderful opportunity they had in the real world of science. So that is one program that we have been running now for seven years. It is now funded by the National Science Foundation. We have one more year left in the grant. We are not sure where funding will come after that, but the interest in the area is strong enough so that we hope to maintain that program.

Congressman Lloyd referred to Saturday Morning Physics, so perhaps I will not discuss that program, but talk to you briefly about a junior high school program that we have started. Again, when we wanted to look at junior high school education, we brought in teachers and university professors to ask them what advice they might give us. In this case, their advice was the following: Junior high school teachers do not look at Fermilab as a resource to them. They do not understand what happens here and they would not normally choose to come here. We think you should start with a program that will bring students and teachers here in a rather informal setting and then from that, you can build a stronger program for working with teachers.

We got together with some junior high school teachers and designed a program which is called Beauty and Charm at Fermilab. Beauty and Charm are names of two quarks, it does not refer to the quality of the staff members. That program is a curriculum unit that was designed by junior high school teachers with assistance from Fermilab scientists. It includes all the materials that a teacher needs to teach a unit in the classroom, and we also run workshops for the teachers to enable them to teach these materials. Finally, the students who study this program are invited to visit the laboratory, which is not ordinarily a possibility for junior high school teachers.

We have been doing this program for four years now. We have had as many as 4,000 junior high school students who have come through the laboratory. Of course they all come on field trips with their parents, so in the meantime we have had a lot of parents who have come and now we are seen as a resource for this particular area.

The goals of this program that were recommended to us were in some sense negative goals; do not teach how many leptons there are and how many quarks there are, and give us the names and all the numbers that go with particle physics that you do. However, do show us science in action, do show us science process, help the students develop an awareness and understanding and appreciation of science, talk about science careers and opportunities for students. You have people in the laboratory at all levels of skill and education. Let the students know that there is a place for them in the world of science. So this is the type of program that we designed.

Again, how effective have we been? We do many of the same things in this program that we do in our other program; however, here one of the sources of information that is most interesting to us are the parents of students. And we get as much information at the soccer field from the parents who say "Boy, my kid went to Fermilab yesterday, it was a wonderful opportunity. He came home and—how can we come out to the lab, I would like to know more about this. Can we come on Sunday." So we get a lot of feedback from the community that indicates we are exciting families about science, not just students.

We would like to be able to do more in the area of junior high school science. We would like to be able to do more in the area of elementary school science. In particular we would like to develop some programs similar to the Oak Ridge Ecological and Physical Science Study Program where students can come and spend a half a day working with hands-on science where their teachers and students can learn together from other teachers. The Laboratory has committed the funds to build a facility which will enable us to bring students, younger students, to the Laboratory, and my job in some sense is to provide the programs that go with that.

We feel it is very important in our area to be seen as a regional resource. We have been working with teachers since day one. We continue to do that, and in fact, the center that we are building, the teachers see as their own and they talk to us about "well when we do this, would you please have a computer hot line, would you please be sure that it is open in the evening", so we feel very strongly that the relationship that we are developing is a collaborative one in which we open the doors and allow the educators to come into the Laboratory.

And I think you realize that this is all done because in some sense we have a very supportive Laboratory Director, who has really been a pioneer in the area of science education. And I cannot tell you what a pleasure it has been for us to work with him. And we are figuring out how after July 1 he is still going to be there giving us advice and sort of guiding us down the right path.

Mr. SCHIFF. I do not mean to interrupt you, Ms. Bardeen, but Dr. Letterman—Chairperson Lloyd and I visited Fermilab and Dr. Letterman said he was going to teach a course at the University of Chicago called Physics for Poets. I thought that sort of summed up everything at one time very eloquently.

Ms. BARDEEN. Yes, he did. In fact, he has always enjoyed teaching the courses for the non-science students. And I think in fact that is something that has translated into our programs, because again, we appeal to the average teacher and the average teacher teaches a wide range of student ability. So we are not just looking at someone who is going to be a scientist, but we are looking at, in general, the student population.

So thank you very much and I will be happy to answer questions you may have later.

[The prepared statement of Ms. Bardeen follows:]

Testimony of Marjorie G. Bardeen
Program Director, Friends of Fermilab
Fermi National Accelerator Laboratory
Committee on Science, Space and Technology
Subcommittee on Energy Research and Development
15-MAY-89

INTRODUCTION

Science and mathematics literacy: national studies delineate the problems and propose solutions for curricular and instructional reform. But, who is going to bring about change? We cannot expect the schools to raise the literacy of the nation all alone. Many outside partners can and must contribute. We can double and triple our efforts by creating innovative partnerships between the education community and national laboratories, museums, and businesses, between formal and informal science programs.

As part of its basic commitment to science, Fermi National Accelerator Laboratory (Fermilab) began offering educational tours for high school students and teachers in 1972. When Leon M. Lederman became Laboratory Director in 1979, educational opportunities at the precollege level were expanded in response to the need in our area to revitalize the skills of current science teachers, to maintain interest in the teaching of science as a career, and to encourage young people to pursue careers in science and engineering. In 1983 Friends of Fermilab (FFLA,) a not-for-profit corporation, was established to facilitate the formation of partnerships among Fermilab, school districts, and public and private funding agencies.

To fulfill its mission to enhance the quality of precollege science education and to promote a broader public awareness and understanding of science, Friends of Fermilab has raised close to $2 million from public and private sources. The corporation is governed by a 24 member Board of Directors composed of Fermilab staff members, civic, business, and education leaders. The Director of Fermilab is a member of the Board. An executive staff of three manages the office. Friends of Fermilab began with one program for 45 participants at a cost of $75,000. This year we are sponsoring 16 programs that directly reach as many as 10,000 people. Up to 60 teachers staff the programs. The FY '89 budget, including operating funds and dedicated program funds, is $450,000.

In order to increase the Laboratory's participation in precollege education Fermilab plans to open a Science Education Center in FY '91. This facility will be dedicated to formal and informal science education programs. The Center will include a teacher resource center, space for large interactive science displays, classrooms and offices. Key programs will include:

- Teacher Training - Training teachers to use laboratories and demonstrations effectively with students will help provide lively and exciting science programs.
- Out-of-school Programs for Students and Parents - Informal science programs will support

and reinforce formal classroom instruction.

- Hands-on-Science - Direct personal experience with the phenomena and principles of science and technology provide a depth of insight and involvement that cannot be matched by less active education.
- Adult Education - All citizens, not only students but also parents, teachers and other adults, should experience the joy of exploration and discovery and learn about the science that impacts societal issues.

In FY '89 15 programs for high school students and/or teachers and eight programs for K-8 students and/or teacher are being conducted at Fermilab. Most are sponsored by Friends of Fermilab. Today, I will describe Friends of Fermilab program development, management and funding, provide an overview of the programs, and discuss their impact. Finally, I will focus on additional needs.

PROGRAM DEVELOPMENT AND MANAGEMENT

Friends of Fermilab has developed a successful format for program development and implementation that allows schools to tap the resources of a national research facility. The format includes two key components: conducting a needs assessment and establishing a program committee. Program development is guided by recommendations from an appropriate needs assessment conducted with educators, community leaders, Fermilab scientists and representatives of Friends of Fermilab. A typical needs assessment workshop includes 20-28 participants, is held on a Saturday, lasts four to six hours, and covers a major program type or a new age group. It is important for Fermilab to listen to the education needs as perceived by the people who teach the students and employ the graduates. National laboratory staff are not necessarily experts in precollege education. However, when they understand what the local priorities for improving science and mathematics education are, they can assess the laboratory resources and determine ways to work in partnership with educators to promote change.

After the needs assessment is a completed, a program committee, composed of two to four local educators (master teachers, department chairmen or instructional administrators) and a Fermilab scientist, evaluates the results of the needs assessment and makes program recommendations to the Friends of Fermilab Program Director. Based on those recommendations Friends of Fermilab executive staff prepares funding proposals, subject to approval by the Board of Directors, and seeks funds from private and public sources.

With the advice of the program committee, the Program Director hires the staff. The staff is responsible for such tasks as program announcement, staff selection, curriculum development, participant selection, follow-up activities, evaluation, program reports, and dissemination.

Strengths of our program development model include:

- developing ownership of the programs among teachers by involving them from the beginning.
- giving teachers leadership roles recognized both by their peers and research scientists.
- establishing continuing communication channels between researchers and teachers.
- utilizing expertise from various groups - teachers, science education specialists, scientists - with minimum interference with their regular job.
- integrating laboratory education programs with exisiting local inservice programs.

PROGRAM FUNDING

Current precollege education programs sponsored by Friends of Fermilab are funded by the U.S. Department of Energy Office of Energy Research, the National Science Foundation, Universities Research Association and various private foundations and individuals. In addition, state of Illinois area education centers and school districts provide support for teachers who participate in inservice programs.

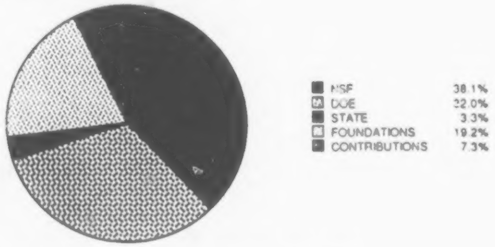

Figure 1 shows the sources of funds 1983-1988.

PROGRAM OVERVIEW

The Friends of Fermilab education programs are developed within a framework that takes into account the mission of Fermilab, the appropriate use of its facilities and the talents and interests of its personnel. Programs for higher grade levels are inaugurated first. At a given level programs begin by bringing students and their parents or teachers to Fermilab in order to establish an awareness of the Laboratory and the role it can play in education. Programs for teachers follow. Thus, it is seen that the high school programs have developed maturity and form a comprehensive program for students and teachers alike. Programs at the junior high and elementary levels are in the early stages of development.

PROGRAMS FOR HIGH SCHOOL TEACHERS AND STUDENTS

Summer Institute for Science and Mathematics Teachers (1983)

Objective: To enhance science and mathematics teaching in the high school classroom.

Format: 45 selected high school science teachers in biology, chemistry and physics and 15 high school mathematics teachers attend an intensive four-week institute at Fermilab. Lecture sessions in the four disciplines are conducted on Monday, Wednesday and Friday mornings by Fermilab physicists and college faculty. On Tuesday and Thursday mornings plenary sessions are held with nationally-known experts lecturing on interdisciplinary science topics. In the afternoon, computer instruction, lab sessions and mathematics sessions with master teachers are held at a local high school. Four "follow-up" sessions are held in each discipline during the academic year following the Institute. Teachers receive a stipend for their participation and earn graduate credit from an area university.

Chemistry West and Physics West (1984)

Objective: To provide opportunities for Summer Institute "graduates" and other science teachers to continue sharing successful teaching materials and strategies.

Format: FFLA sponsors Physics West and Chemistry West, network organizations for area teachers. Each group meets monthly in a local school or college in order to share skills, teaching strategies and materials for the high school science classroom. 550 teachers are on the mailing lists.

Topics in Modern Physics (1987)

Objective: To introduce modern physics topics in high school courses.

Format: This program is designed to update high school physics courses in Northeastern Illinois by augmenting the curriculum and improving instruction. In 1987 a group of high school physics teachers and Fermilab physicists developed a teacher resource book on modern physics topics. Using the manual as a text, the group trained a cadre of 20 master teachers as inservice leaders in the summer of 1988. The three-week workshop curriculum included background lectures on modern physics, training sessions on sound science instruction and inservice techniques, and laboratory sessions where participants tried out classroom materials. During the workshop the participants developed a comprehensive physics inservice plan which is being implemented in existing inservice programs of local districts and State of Illinois Educational Service Centers. A follow-up program conducted through established physics teacher networks will support the efforts of teachers to update their classes. Teachers receive a stipend for their participation and earn graduate credit from an area university.

Physics Mini-Courses (1987)

Objective: To share materials and strategies for teaching particle physics and cosmology at the high school and college introductory level.

Format: Mini-courses consist of lectures by Fermilab physicists or physicists affiliated with Fermilab and demonstrations by FFLA master physics teacher based on the format developed in the Summer Institute for Science Teachers. Teams are available upon request to make presentations across the country. Presentations have been given in Illinois, Florida, Montana and Mexico City and are scheduled in Wisconsin and Texas.

DOE Teacher Research Associates Program (1983)

Objective: To recognize superior science teaching and expose teachers to state-of-the-art scientific research equipment and procedures.

Format: Fermilab hosts a summer research program for high school teachers. Candidates for the national program are nominated by their state Departments of Education. Candidates for the regional program are nominated by their school districts. Employment selection is made by laboratory supervisors. Teachers are assigned to a scientist or engineer involved in a research project at one of the participating institutions, and make contact with many professional researchers. Teachers learn to acquire data and report results in a scientifically acceptable manner, skills directly transferable to the classroom. Other DOE national laboratories participate in the national program. Eight corporate research laboratories in the Illinois High Tech Corridor also participate with Fermilab in the regional program in operation since 1983. Over 80 teachers have participated in the program since its inception.

Saturday Morning Physics at Fermilab (1980)

Objective: To introduce selected high school students to topics in modern physics.

Format: Three times each year, a series of ten lectures is conducted at Fermilab. One hundred students from area high schools are selected by their schools to participate in each series. Lectures on topics such as "Accelerators and Detectors", "Special Theory of Relativity", "Leptons and Hadrons" and "Cosmology" are delivered by Fermilab staff experimental and theoretical physicists. The program also includes lab tours, demonstrations of equipment and instruments, and tutorial sessions led by physicists to discuss in depth the material presented in the lectures. Saturday Morning Physics has "graduated" over 3000 students.

Target: Science and Engineering (1980)

Objective: To conduct an apprentice research program for gifted minority high school students.

Format: Students are nominated by their schools and selected by a committee composed of Fermilab Equal Opportunity Office personnel, Fermilab scientists and area educators. The 25 selected students, the majority from Chicago schools, spend six weeks in the program. In the mornings they work side-by-side with a scientific, engineering or technical mentor at Fermilab. In the afternoons the students attend classes and receive assistance in the preparation of an individual or group research project, which is generally based on some aspect of the morning work. The students receive a combination of a salary and a stipend for their participation in the program. 125 students have participated in the program since its inception. Most have gone on to college, many to major in science or engineering.

DOE High School Honors Research Program in Particle Physics (1987)

Objective: To expose gifted high school students to the research done at a world class particle physics laboratory.

Format: Fermilab hosts a research program for gifted high school students. Participants in this program join groups of physicists and graduate students doing frontier research in the properties of elementary particles. The program includes lectures by Fermilab staff physicists, lab tours, and tutorial sessions, as well as on the job experiences. Students spend two weeks working and studying at Fermilab. They are supervised by master high school physics teachers and live at an area university. Students in this program come from the fifty states, the District of Columbia, Puerto Rico and six foreign countries. Six other DOE national laboratories participate in this program.

PROGRAMS FOR ELEMENTARY AND JUNIOR HIGH SCHOOLS

Beauty and Charm at Fermilab (1985)

Objective: To introduce junior high and middle school students to particle physics

Format: A particle physics curriculum for the junior high classroom has been developed. Teachers attend workshops to become familiar with the curriculum, which includes several simple hands-on experiments which portray concepts such as "How Small is Small" and "How to Measure What We Cannot See." The teachers can purchase a "kit unit" including all materials for the classroom experiments, a manual outlining the day-by-day conduct of the curriculum and audio-visual materials to supplement the curriculum. After completion of the classroom unit the teachers may accompany their students on a visit to Fermilab to tour working areas and visit with a Fermilab physicist. Over 70 teachers have been trained in the program and some 800 students visit the Laboratory each year.

Wonders and Magic of Science (1985)

Objective: To reward outstanding elementary school science students and encourage them to continue their interest in science.

Format: FFLA sponsors a science show for area elementary schools during National Science and Technology Week. Schools participate by extending an invitation to two outstanding science students in grades three through six. They and their parents come to a Saturday morning program where high school science teachers entertain the guests with the wonder and magic of science. Students receive a demonstration kit based on one of the show's activities which they can share with their classmates. The program ends with refreshments. The program has grown to include two shows with a combined audience of some 1200 students and parents.

PROGRAMS FOR STUDENTS OF ALL AGES AND THEIR TEACHERS

Cryogenic Magic Show (1982) Electricity Magic Show (1989)

Objective: To demonstrate the change in properties of materials when they are exposed to very cold temperatures and to demonstrate properties of electricity..

Format: These programs are designed to turn on teachers and students to science. Fermilab engineers have developed liquid nitrogen demonstrations and electricity that can be presented to teachers and students of all ages. Presentations are given at schools, for youth groups and in conjunction with other science activities upon request.

Weird Science (1986)

Objective: To promote the use of demonstrations in chemistry classrooms as an effective teaching method and motivational tool for students.

Format: "Weird Science," a program to turn on teachers and students to science, is an outreach program of FFLA. Four Summer Institute chemistry instructors have developed a repertoire of science demonstrations. Presentations are given at various local, state, regional and national conferences. These presentations model effective teaching methods and provide teachers with successful classroom demonstrations.

Hands-on-Science (1989)

Objective: To give students direct experience with the phenomena and principles of science and technology.

Format: A travelling collection of interactive science activities with accompanying teaching materials is available on loan to area schools. Teachers are able to provide for their students a depth of insight and involvement with science that cannot be matched in most regular classroom programs.

MATERIALS PROGRAMS

Classroom Materials (1984)

Purpose: To provide classroom materials that enhance science instruction.

Format: A variety of classroom materials have been developed in conjunction with FFLA education programs. These are made available free of charge or at cost to teachers. Included are Beauty and Charm curriculum materials, Topics in Modern Physics videotapes which contain some of the Saturday Morning Physics lectures, Topics in Modern Physics Resource Book and posters.

Resources for the Science Classroom (1984)

Objective: To familiarize K-12 teachers with the resources available to them in Northern Illinois.

Format: FFLA has produced Resources for the Science Classroom, a manual listing over one hundred fifty opportunities for teachers to enhance the teaching of science. A data base which includes federal, state, local, not-for-profit and corporate programs, tours, materials and "giveaways" has been created. The listings are printed into a bound manual for easy copying and are available to schools at no charge . A second edition was published in 1987, and the resources entered into a new data base to permit selective listings to be prepared upon request.

PROGRAM IMPACT

Friends of Fermilab attempts to ascertain the long-range impact of the major education programs by surveying the participants. In general, we can say that the programs have made a significant difference in the participants' lives. The following quotes illustrate the type of response we get. A teacher in the Summer Institute says, "Excitement has been infused into fifteen classrooms and into hundreds of young people studying physics for the first time. These students are getting an exceptional education, after all, they would tell you...'My teacher spent the summer at Fermilab!'" A student who attended Saturday Morning Physics remarks, "The lectures alone made me decide to go into physics. The lectures gave me a much better perspective of what physics is all about than one could ever get from a high school physics class."

The success of the Friends of Fermilab model is demonstrated by the rapid growth of our programs, the interest in and involvement of local teachers in our programs and by the impact these programs have had on area schools. Friends of Fermilab has become a catalyst for regional change, extending the impact of Fermilab programs to include that of many others organized by former participants and staff members. Teachers with a new enthusiasm for teaching also have a renewed interest in sharing with one another through inservice and continuing education activities.

ADDITIONAL NEEDS

23 DOE laboratories sponsor precollege education programs. Included are the two national programs, the DOE High School Honors Research Program and the DOE Teacher Research Associates Program, as well as many local initiatives such as those sponsored at Fermilab. However, we have only begun to tap the remarkable resources that national laboratories represent.

In July 1988 a report (DOE/S-0065) of the Energy Research Advisory Board was issued to the Department of Energy on Science and Engineering Education. The panel recommended that the Department base its precollege programs on guidelines which ensure that programs reach the largest number of students and are most effective in retaining them in science and mathematics. Among those guidelines were:

- Concentrate on developing programs for teachers. Emphasize programs that 1) help teachers enhance their science skills and understanding; 2) provide teachers (and students with hands-on activities; and 3) encourage understanding of the relationships between science, technology and society.
- Some programs should give special consideration to young students and their teachers at the elementary and middle school level.
- Develop and support vigorous programs to stimulate and nurture the interests of young women and underrepresented minorities to participate more fully in DOE education programs.

In addition to resources needed for current high school programs, we need support for elementary and middle school programs, especially for programs targeted at young women and minority students. We need resources that permit individual laboratories to work with school systems in response to local and regional needs.

FINAL REMARKS

When Friends of Fermilab began in 1983, it was not at all clear that a research facility was an appropriate setting for major teacher inservice programs. Teachers and students have given us the answer. "Yes!" Precollege education programs work at Fermilab because it is not business as usual. Teachers come to a world class high energy physics research laboratory for a unique opportunity to witness science conducted at the frontiers of human understanding. Teachers gain invaluable experience learning from leading research scientists like Laboratory Director and Nobel Laureate, Leon Lederman. Students have an experience in science that broadens and enriches their attitudes and develops their appreciation for science. Students see, perhaps for the first time, what the world of science is really like, and they like what they see!

Ms. LLOYD. Thank you very much. Dr. Veigel.

STATEMENT OF DR. JON M. VEIGEL

Dr. VEIGEL. Yes, ma'am. Thank you very much.

Oak Ridge Associated Universities is not only a consortium of 49 universities, it is also the Department of Energy's first or second oldest national laboratory. Since 1946, we have been responsible for all of DOE's fellowship programs, and given this experience we recognize full well that the country is not interested in the subject of science education for esthetic reasons. The interest is motivated by the need for action. At a minimum, we need to move and do more with respect to science education in order that we at least tread water with respect to the competitiveness and productivity situation we find ourselves in now. And we need to do even more if we expect to regain the competitive edge that we have formerly enjoyed.

Now in 1957 and again in 1965, the Nation experienced a change in national attitudes about science education. I suspect we are at a comparable point in 1989. Instead of being driven by the Sputniks and by great society, it is this issue of international competition. And I personally believe that the rapid transformation we are seeing in the way private sector R&D is done in this country will also impact the way science education is handled.

What we really need to pay attention to is the quantity and quality of scientists that we deliver to the point of need. Now one convenient measure of this is the number of science students that we have, but it is by no means the single best measure, nor the only measure.

Considered from this context, it is easy to be pious about science education. It is less easy to see what we can do that will produce cost-effective results. I have five questions that I believe define the problem.

1. How do we keep students from making academic decisions today that will foreclose their making science career choices tomorrow?
2. How do we get commitments to science and engineering careers?
3. How do we maximize the retention of science grads in jobs that need their science or engineering backgrounds over the course of a career? The public has made a tremendous investment in these people and if they are lost to selling real estate, we all are suffering for that.
4. How can we retrain the now technically obsolescent so that they can make contributions?
5. How can the Federal Government develop programs of action that are balanced among K through 12, undergraduate, graduate and in-career training; and be effectively coordinated across all agencies and industries dependent on a trained scientific cadre to meet their mission requirements; and finally, focused on highly leveraged intervention points that can provide examples of success for replication among our states?

Now I think there are some examples that I would like to cite of potential leverage points here. Number one, something like 40 percent of all black students in this country are produced by 50 school districts in this country, out of a total of 16,000 school districts. Does that offer us opportunities in what we see coming along for the future? There is a selection of about 40 liberal arts colleges in this country that produce a disproportionate share of the graduate students in science engineering. What are they doing right, how can we help them to do it better and how can we replicate that experience in other colleges?

I had personal experience over the last few years in North Carolina at a very prosaic level with respect to education. I think, Madam Chair, it goes to your point about reaching the more average students. The most complex piece of technology that is still assembled on site for your individual home is your air conditioner, your heating and ventilating and air conditioning piece of equipment. And that is generally assembled on site and proved out by somebody who is very ill trained to know whether it is energy efficient or not. And if it is energy efficient, you can save 20 percent on your annual bill. We ran a program for a number of years training technicians in community colleges how to make air conditioners energy efficient, and you cannot imagine a more prosaic bread and butter kind of issue and you cannot imagine an issue that has more direct impact on most people in this country than how much their air conditioner costs them, and this is science education, this is energy education at its most fundamental level.

Now the labs, as we have heard today, are certainly the core, they are the anchor, they are the foundation of our ability to do much of the work we are talking about. In my personal belief, though they be necessary, they are by no means sufficient. We need to take advantage and pay attention to the kind of integrating experiences that will allow us to have these leveraged kinds of impacts.

Oak Ridge Associated Universities has been involved in a number of these programs over the years. In most of them, the number of students that we have applying in ratio to the number of positions available, ranges from two to eight people, eight times as many people applying as we can accommodate. We work in programs like the challenge programs for minorities where we identify them at the junior college level and work with them, get our member universities to agree to commit at the junior high school level, that they will support these people through their graduate degrees. Now at the junior high level, that is a commitment I suspect that is hard for most kids to appreciate. I suspect also that the parents can appreciate that.

We do similar integrated kinds of programs with high school teachers. But I want to recommend for your consideration today five possibilities that I do not think you have heard yet this morning.

I think we are in a position today where we are—it is a good opportunity for us to establish a national coalition for science and engineering education and the American economy, where I believe the national laboratories, American higher education and American industry, which has a particular need for the scientists and engineers to carry out their work, the energy intensive industries especially can get together and do a coordinated comprehensive approach to science education. We are all in this together and it is a terrible misuse of our resources not to look at the coordinated kind of possibilities.

Secondly, I believe a national center for energy education is appropriate now, where the kind of planning and comprehensive approach to these things on a national level will get us past the point where we have a menu of projects that represent a why-not list of projects. They are all good, I do not deny that. I would like to see some consideration given to their overall balance in whether we are accomplishing our needs.

I would propose an establishment of a center for instructional technology research and development. ORAU is doing a lot of work with the Department of Defense on things like interactive video discs and so forth. Very little of those technologies and that kind of software is being applied to the issue of science education and I think that is technology transfer at its most fundamental and its most basic, and I think there is a lot of work that can be done there.

We are running and have run for a number of years and propose expanding that an education and labor market analysis program where we look, on behalf of the Department of Energy, at what the needs for trained scientists and engineers is going to be over the coming decades. And I think that provides the underpinning of many of the statistics that all of us are depending on.

And finally, we believe, as is happening at other laboratories, that establishment in Oak Ridge of a science and engineering education center is timely and appropriate. On an average, we have got something like 300 students per night in Oak Ridge, and there is no place on the local economy for them to stay. As a way to finance this, we are exploring the possibility of a joint venture between Oak Ridge Associated Universities and a local hotel in Oak Ridge where those two groups, ORAU and the hotel, would finance the residential and eating facility part of it and the Department of Energy's guarantee would be in terms of covering so many bed nights per year on an annual basis. We estimate that the number of bed nights are in the range of 20,000 to 30,000 bed nights per year of people at all levels from undergraduate students to postdocs who could occupy these facilities, and I think do it in a cost effective kind of a way.

I believe that we are at a cusp in our ability to do things here and it is time for us to move out in the kind of surge for science education that I think is not only appropriate but needed in the point we find ourselves in today.

Thank you, Madam.

[The prepared statement of Dr. Veigel follows:]

BRIDGES INTO SCIENCE/ENGINEERING CAREERS: EDUCATION AND THE FEDERAL LABORATORY SYSTEM

Testimony for Hearings of the
Subcommittee on Energy Research and Development

by
Dr. Jon M. Veigel, President
Oak Ridge Associated Universities

May 15, 1989
Chattanooga, Tennessee

Introduction

In the 1980s, American citizens have been shaken by a series of serious warnings that we are no longer the most productive nation, the acknowledged leader in technological innovation, the leading-edge competitor, or even the most scientifically literate nation. At the epicenter of these warnings is the issue of education and career preparation in the fields of science, mathematics, and engineering. Our national agenda for the next decade must address the quality of education, the potential shortfall of scientists and engineers, and the general lack of understanding of science.

In 1957, and again in 1965, the nation experienced a change in national attitudes about, and programs for, science education. We may be at a comparable point in 1989, driven now by competitiveness, not by the Sputniks and Great Society of those years. An accelerated evolution of education for science today will parallel the rapid transformation of private sector R&D now underway.

It is easy to be pious about science education; it's less easy to see what to do that will produce cost-effective results. I have five questions that define the problem:

1) How do we keep students from academic decisions that foreclose later career options?

2) How do we get commitments to science and engineering careers?

3) How do we maximize retention in jobs that are based on science or engineering over the course of a career?

4) How can we retrain the now technically obsolescent so they can make contributions?

And finally,

5) How can the federal government develop programs of action that are:
   - balanced among K-12, undergraduate, graduate, and in-career training;
   - effectively coordinated across all agencies and industries dependent on a trained scientific cadre to meet their mission requirements; and
   - focused on highly leveraged intervention points that can provide examples of success for replication among the states?

I believe that ORAU has developed an innovative approach that will address these questions. Our plan revolves around the following initiatives:

- National Coalition for Science and Engineering Education and the American Economy
- National Center for Energy Education
- Center for Instructional Technology Research and Development
- Oak Ridge Science and Engineering Education Center

To give you the sense of ORAU's experience to comment on these issues, I'd like to review our programs, then detail the initiatives we believe would address the problem we're here to discuss.

OAK RIDGE
ASSOCIATED UNIVERSITIES

As a program-dedicated national laboratory in the DOE system, ORAU has had education as a primary focus from just after World War II. Since its formation by the Atomic Energy Commission in 1946, ORAU has educated and trained scientists and engineers through collaborative research participation appointments at federal laboratories, fellowships, training programs, and a host of related activities. As a not-for-profit consortium of 49 colleges and universities and a management and operating contractor for the Department of Energy (DOE), ORAU develops and administers programs that provide special technical education and training opportunities for precollege students and teachers, undergraduate and graduate students, university faculty, and postgraduates. Recognizing the changing demographic patterns, we recruit applications for all ORAU programs from underrepresented ethnic minorities and from women, and we have several programs targeted specifically for Historically Black Colleges and Universities (HBCUs) and for minorities and women.

With over 40 years of experience in education, training, and research, ORAU is a recognized leader in this area. Last year for example, 111 postdoctoral participants had appointments in 19 R&D facilities, and 80 faculty members participated in ongoing research at six federal laboratories. In addition, 109 fellows pursued graduate study and research in specific energy technologies at 29 universities nationwide, and 315 undergraduate and graduate students participated in research at seven facilities. Finally, focusing on the precollege level, 110 teachers and 30 students participated in our summer and academic-year programs, while an estimated 4300 middle and high school students benefitted from ORAU-sponsored lectures by Tennessee scientists.

In her letter of invitation to speak before this subcommittee, Ms. Lloyd referred to the federal laboratory as a "treasure chest of learning" with a significant potential impact on students' career decisions. ORAU has helped to build bridges to those treasure chests for many years. We currently have programmatic linkages and administrative procedures in place with 50 different federal R&D facilities in the United States and, more recently, with several laboratories in the European research community. Obviously, the laboratory with which we work most closely is the Oak Ridge National Laboratory (ORNL) where last year we placed about 300 participants from all levels---precollege to postdoctoral participants.

INITIATIVES

Among the major workforce and education challenges we face today are the quality of precollege science and mathematics instruction; the shrinking pool of 18- to 22-year-old students; a disproportionate decline in number of white males; underrepresentation of minorities and women in science and engineering fields; declining interest in science and engineering careers; fewer students pursuing science and engineering graduate degrees; science/engineering faculty shortages; and science/engineering retirements.

ORAU has put together a comprehensive, aggressive plan to link the resources of the federal laboratory system with those of the academic community to address these challenges. Our action strategy consists of the following roster of activities and programs:

- National Coalition for Science and Engineering Education and the American Economy
- National Center for Energy Education
- Center for Instructional Technology Research and Development
- Oak Ridge Science and Engineering Education Center

The National Coalition for Science Engineering Education and the American Economy will draw together DOE's diverse laboratory system, the nation's higher education institutions, and energy-related industries to help ensure a well-educated cadre of scientists and engineers. The growing importance of science education to the Department's ability to fulfill its mission affords a vibrant opportunity for DOE to emerge as a national leader in the quest for educational excellence. DOE recognized very early the natural unity of purpose between the federal government and the academic community. The Department's three university consortia---Associated Western Universities, Northwest College and University Association for Science, and ORAU---represent 132 colleges and universities in 32 states. They interact with more than 60 DOE facilities with thousands of students involved annually.

Building on over four decades of educational experience, ORAU has proposed the establishment of a National Coalition for Science and Engineering Education and the American Economy. With DOE consortia and national laboratories, and the active involvement of the energy and energy-intensive industries, the Coalition will offer "single-stop shopping" for aggressive and balanced DOE educational efforts. The Coalition will provide input to and oversight of three centers described below.

The Center for Education and Labor Market Analysis will assess trends in employment needs, adequacy of future supplies of new graduates, effectiveness of educational support programs for various scientific and engineering disciplines, and needs for specific education programs. Their data, trend projections, and policy analyses will enable DOE policymakers and members of the Coalition to plan, implement, and evaluate effective education programs.

The National Center for Energy Education will be the linchpin of the Coalition. Center activities will stretch from an active search for the most innovative and successful educational ideas, to their inclusion in a carefully balanced plan of DOE action, to carrying out unique programs of national scope. One possible activity is ORAU's proposed "Young American Scientists" program targeted to grades 6-9 during the school year and grades 10-12 with Summer Science Camps. The program will establish a national network of universities hosting two-week summer science camps for high school students. Emphasizing hands-on involvement in science and personal interaction with role-model R&D professionals, the summer camps will address the issues of career choice and educational opportunities while teaching science annually to an average of 1000 students from across the country. The program is designed as a "grass-roots" intervention program to increase the total pool of high school students interested in science and engineering careers.

Other examples are "Focus Energy"---a menu of energy education programs aimed at the key decision makers across the country-- and a proposed "Women and Minority Energy Research Associateships" to recruit scientists from the fastest-growing segment of the population.

The Center for Instructional Technology Research and Development will ensure that science and engineering education at all levels will benefit from the best equipment, educational software, and curriculum materials. Products of the Center will be developed to meet unique needs and/or will be based on existing systems applied to science education. A collateral benefit will be applications of the same technologies for use by DOE to service its own training needs.

The Oak Ridge Science and Engineering Education Center will serve as the focal point for science and engineering education and research participation activities in Oak Ridge. The Center will support a wide range of programs sponsored by government agencies and academic institutions and will serve as a model for replication at other laboratory sites where increased interaction with the academic community is desired. The individuals who come to Oak Ridge to participate in ongoing research and education programs and activities described earlier are, with few exceptions, responsible for their own housing. Short-term guests generally stay in hotels; long-term guests rent apartments or houses. Unfortunately, these individual arrangements make it difficult for participants to interact with one another. To maximize the effectiveness of science and engineering education programs, Oak Ridge needs a center that will bring participants together, stimulate communication, and encourage collaboration. Only in this way can the potential value of these complementary programs be fully realized.

The multipurpose facility will serve as the center for program activities and will provide housing for program participants. In addition to housing accommodations, the Center will provide lecture rooms, a computer laboratory, an Energy Experiments laboratory for precollege training sessions, recreation/lounge area, and study areas. Ongoing programs such as the DOE Lab Co-op program, the Science and Engineering Research Semester, ORNL User Groups, and ORAU short courses will make use of the Center facilities. Certain activities of local higher education institutions, such as Roane State Community College and the University of Tennessee, are also expected to use the Center. A graduate education center relying on the combined resources of ORAU member institutions and the Oak Ridge research community may be established as one of the Center's primary activities.

The Center will also support other unique education activities. Primary and secondary school students, under supervision of their teachers, will conduct energy-related experiments in an Energy Experiments Laboratory. This laboratory will contain exciting, hands-on experimental set-ups and instruments (normally not available in school laboratories) to illustrate scientific principles and theories in novel ways. (The Energy Experiments Laboratory is a part of the Young American Scientists initiative mentioned earlier).

CONCLUSION

The good ideas do not stop with these major initiatives. ORAU is working to expand the successful high school teachers program, STRIVE. Following a three-year pilot effort at ORNL, STRIVE is ready for replication at other DOE laboratories. Another productive program ready for expansion and replication is ORAU's Minority Challenge Program for High School Science and Engineering Students. Known as Challenge, the regional model was initiated last summer with a two-week science camp for 30 minority students and continued through the academic year with activities designed to nurture and sustain the interest generated by the summer program. The program has attracted a great deal of media attention and received acclaim from student participants, parents, and school officials.

These initiatives and program models are real solutions to the problems we have identified as a nation. Oak Ridge Associated Universities stands ready to offer our expertise and experience toward reaching our common goals. Together, we can build the bridges we all need.

JINKERSON:bj

Jon M. Veigel
President
Oak Ridge Associated Universities

Dr. Jon M. Veigel is the president of Oak Ridge Associated Universities, Oak Ridge, Tenn., a private, not-for-profit organization of 49 colleges and universities and a management and operating contractor for the U.S. Department of Energy.

Veigel oversees corporate activities and the four ORAU divisions: Energy/Environment Systems, Medical Sciences, Training and Management Systems, and Science/Engineering Education.

Before joining ORAU he served for over seven years as president and executive director of the nonprofit Alternative Energy Corporation (AEC) in Research Triangle Park, North Carolina. The AEC is a cooperative joint venture of all North Carolina electric utility organizations and the state's Utilities Commission with a mission to improve the efficiency of energy production and use. He was appointed by two govenors to the North Carolina Energy Development Authority and served as elected Chairman.

From 1978 through 1981 he was an assistant director and division manager of the Solar Energy Research Institute in Golden, Colo. Veigel also headed the Alternative Energy Division of the California Energy Commission beginning in 1975, and prior to that was program manager for Energy, Office of Technology Assessment, United States Congress where he held a Congressional Science Fellowship.

Veigel has nearly a decade of full-time college teaching experience. In recent years he served as an Adjunct Professor of Public Policy while offering courses in energy policy at Duke University.

He is currently serving on the board of directors of the American Council for an Energy Efficient Economy, the ORAU Foundation, the Tennessee Center for Research and Development, the Council on Research and Technology, and the Southeastern Universities Research Association. He serves on advisory committees of the National Energy Conservation Coalition, Pace University, and Lawrence Berkeley Laboratories. Veigel is also serving as Chairman of the Oak Ridge Community Foundation.

Veigel earned a bachelor's degree in chemistry from the University of Washington, and completed his doctorate in physical-inorganic chemistry from the University of California, Los Angeles.

A native of Mankato, Minn., Veigel and his wife, Carol, live in Oak Ridge.

4-89

Ms. **Lloyd**. Thank you very much for excellent testimony. Lee, would you please proceed.

STATEMENT OF DR. LEE L. RIEDINGER

Dr. **Riedinger**. I enjoyed being here to see Mrs. Lloyd and Mr. Schiff and also the members of your excellent Subcommittee staff, who are to be complimented.

I would like to bring my perspective to this problem from two standpoints. One is as a professor of physics at the University of Tennessee and Director of the Science Alliance program, but also as a father of two daughters, one of whom got her Bachelor's degree in chemistry yesterday and the other being a high school science student. I hope they both continue in science.

Ms. **Lloyd**. I am very happy that you brought up the subject that we are placing emphasis today, that we do not want to overlook women, minorities in this process. You referred to your daughters, I am happy to say that my daughter-in-law is here for this hearing and she just got her degree and she is also the mother of a three-year-old. So there are a lot of good things happening.

Dr. **Riedinger**. That is to be very much applauded.

Ms. **Lloyd**. You allow me that personal note.

Dr. **Riedinger**. Of course.

Mr. **Schiff**. My daughter is only 11 years old, but my wife has a Bachelor's degree in mathematics.

Dr. **Riedinger**. Good. Well, physics of course is the best field, but any science will do. [Laughter.]

I would like to I guess talk about the problem first of all. I guess I disagree with some people in the country that attribute the problem of science and engineering students to the school system and to the course work. When I compare the science courses that my daughters have taken in high school to what I took 30 years ago, there is no comparison, they are far better, far more detailed, far better taught than what I had 30 years ago.

Instead, I think the problem rests with a lack of inspiration and nurturing of the students. They have to be inspired about science and engineering. When I was a student it was Sputnik that did this inspiration. Today it is difficult to find one issue that provides that inspiration, but we need to find some way to inspire and nurture this interest of students in science. I would like to find a way to do that.

To accomplish that, I think I would like to suggest two things. One is summer programs. A lot of people have spoken about that. I think we need more and better summer programs for the children at the high school and college level. My second point that I would like to make as I go through this is that I would like to emphasize the collaboration of universities and national laboratories in doing this. I have some fear of national laboratories setting up too much of a structure without the cooperative input of universities who are expert at education. We do already a lot of different programs, summer programs, for students.

I direct the Science Alliance which is a State of Tennessee Center of Excellence and our role is to bring a closer collaboration in the sciences between UT-Knoxville and Oak Ridge National Laboratory. And one of the programs we do is a summer program for college science majors. We bring them to campus for ten weeks, we pay them a stipend, some of them work at the University, some at Oak Ridge National Laboratory, and it works very well to keep students at that level interested in science.

That is all State money. We spend $300,000 of State of Tennessee money on that program. Also there is the Tennessee Governor Schools Program where about 150 students per summer come to the Knoxville campus for the Governor's Schools in science, to get inspired and nurtured in science.

Jon has talked about a variety of things, they do an excellent program in STRIVE, which we collaborate in a bit, to try to bring that further training and inspiration to high school teachers.

I emphasize the summer programs as being a place where the Federal Government should put its emphasis because I think the schools are doing a fairly good job in academic year training, but the students need to be inspired in the summer to continue their study of science. For example, the programs need to become bigger and better. The State of Tennessee, through Ms. Farmer, runs a DOE program, a summer honors program that Ms. Joseph mentioned, but it only gives an opportunity for seven State of Tennessee high school students to go to a national lab in the summer, and a lot of good students, science students in high school miss that opportunity. That needs to be expanded tremendously, I feel.

In my written testimony I describe a program where perhaps a university and a national laboratory working together could accommodate 300 high school students for the summer, and they should not only get training with sophisticated scientific equipment at the national laboratory, but I think they should get enrichment courses through the university end of the collaboration. There should be courses in FORTRAN, courses in astronomy, courses in biochemistry, general courses, but things that they cannot get in high school in most cases, which they will need if they are going to proceed on to a career in science.

Also I envision a program at the college level. As we discussed—a lot of people discussed—there are a lot of programs for college science students, but I envision a university and national laboratory working together to maybe have 200 students coming to the campus and the national laboratory for the summer, once again using the faculty who are available to help guide the students and the scientists at the laboratory to help do that. That would be a research program for maybe ten weeks.

The third part of the program I described was a high school teacher program, and that is being done through STRIVE now and through other programs on a small basis, but I think that needs to be expanded.

And once again, I would involve the university involvement because the high school teachers need to get academic credit to further their progression of their careers in high school teaching. They may want to take courses of different types in science in the summer.

This is an expensive program, what I just talked about, it would involve two to three million dollars per university/national laboratory collaboration. That is a lot of money, but I think it is an amount of money that needs to be spent. But I think the money can be cost-shared. For example, the program I direct, we use State of Tennessee funds to the tune of $300,000 per summer for our college student summer program. The State should be asked to cost-share part of this package I believe.

In addition, I think that the Federal Government funds for such a summer program should come from various sources, not only from the NSF or from the civilian R&D part of the Department of Energy, but also from the military R&D part of the Department of Energy, because the supply of students will affect not only the universities of the future, civilian R&D of the future, but critically will affect our progression in military R&D in the country.

So in summary, I think summer programs are the keys. Certainly the instructional programs need to be improved, but I really think that the good high school children with aptitude toward science and math need to be grabbed in high school and need to be stimulated and nurtured through exciting summer programs. A few of them get that opportunity now, but too few. More of them would maintain interest in science and see the excitement of science if they could go from the simplicity of the high school courses, in a sense, to the fascinating complexity that they would see in the summer at the national laboratory/university complex. And if we could somehow have funds to do these summer enrichment programs for more high school science students, I think our country would benefit tremendously in the next decade or two.

Thank you.

[The prepared statement of Dr. Riedinger follows:]

Nurturing of Science Students

A Cooperative Venture of Universities and National Laboratories

TESTIMONY OF

Lee L. Riedinger

Director, The Science Alliance
and
Professor of Physics
at
The University of Tennessee, Knoxville

Before the Subcommittee on Energy Research & Development
Committee on Science, Space, and Technology
U. S. House of Representatives

May 15, 1989

Nurturing of Science Students

A Cooperative Venture of Universities and National Laboratories

by Lee L. Riedinger
Director of the Science Alliance at the University of Tennessee, Knoxville
Professor of Physics, the University of Tennessee, Knoxville

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American society is increasingly reliant upon technology and science, but too few students choose to make a career in science, as opposed to finance, law, or management. The forefront of our country's research equipment is becoming more complex, expensive, and breathtaking, but these extreme aspects of that technology deny students easy access to it for educational purposes. The detailed scientific curricula available to students at the high school and college level easily surpass, in my view, those available to previous generations, but too few students are being exposed to the *excitement* of science.

All of the above dilemmas have contributed to the decreased production of scientists and engineers in the U.S. In my view, one way to reverse this trend is to carefully nurture those students with mathematical and scientific aptitudes by carefully bringing them into contact with our country's foremost scientific laboratories and universities. As the following testimony will demonstrate, this can best be achieved by developing close collaborations involving universities and national laboratories.

1. The Science Alliance

My views on this matter have been shaped, to a large extent, by my teaching and research experience as a nuclear physicist at the University of Tennessee, and by my work during the last few years as director of the Science Alliance program at UT. A state-funded Center of Excellence now in its fifth year of operation, the Science Alliance is the oldest and largest of the Centers of Excellence established by the Tennessee Higher Education Commission. The Center's mission is to increase the capabilities and visibility of the sciences at UT through close collaboration with the science units at Oak Ridge National Laboratory (ORNL).

This mission is accomplished in a number of ways. The Science Alliance promotes the hiring of world-class researchers to fill joint UT/ORNL posts as "Distinguished Scientists." The combined resources and capabilities of the two institutions allow us to attract leading scientists at the tops of their professions. Currently, nine Distinguished Scientists work in areas ranging from physics to geology.

The Science Alliance also provides funding for UT faculty and their ORNL associates to purchase sophisticated scientific equipment. Our funds generally provide partial payment for this equipment and act as a magnet for the remainder, which often comes from federal matching money. The Science Alliance also supports joint UT/ORNL institutes. For example, the Joint Institute for Heavy Ion Research is housed in a university-owned building at ORNL and serves as a focal point for 50 atomic and nuclear physicists from across the world to come and work on research at Oak Ridge.

But perhaps the most important Science Alliance initiatives are its educational programs. Because we are acutely aware of dwindling supply of scientists being produced, we spend a significant portion of our funds on programs aimed at bringing outstanding students into the sciences and keeping them there. For example, Science Alliance stipends are added to the regular UT stipends for graduate students in order to attract and keep better students in graduate science studies at UT. These extra stipends have had a profound affect on the ability of our science departments to bring exceptional students to UT for graduate study. Another way we are involved in education is the Science Alliance Summer Research Program for Undergraduates. In this program, approximately 100 college science students are brought to the University of Tennessee for ten weeks of research with UT and ORNL personnel. The undergraduates are currently paid a stipend of $2,500 (plus a small travel allowance), and their time in East Tennessee is spent getting firsthand knowledge of the excitement associated with high-level scientific research. The primary goal of this program is to provide an inspiring research experience for talented science students, with the hope that they will continue onward to graduate studies in scientific areas.

The undergraduate Summer Research Program has met with tremendous success and can act as a role model for large-scale programs on a national level. The program is funded entirely by state resources, and it annually accounts for $300,000 of the total $4 million given each year to the Science Alliance by the state of Tennessee. The ORNL scientists and UT faculty overseeing the students are extremely enthusiastic about the program, which has consistently attracted high-quality students who might otherwise have pursued opportunities outside of science and technology; a number of the student participants have since returned to UT for graduate work in the sciences. The students themselves, who come from across the country, are also very enthusiastic about the program because it provides for most of them the first excitement of contact with a forefront research program.

2. Suggestions for Future Programs

The Science Alliance has demonstrated the desirability and feasibility of close interactions involving a large university and a federally-funded national laboratory. Combining their resources clearly enables the two institutions to accomplish more than either could on its own, while permitting each to capitalize on the unique capabilities of the other. UT and ORNL's shared experience in hiring distinguished scientists; co-funding major pieces of equipment; creating and operating joint institutes; and administering summer research programs, all convince me that such collaborations may be the best way to nurture students with scientific and mathematical aptitude, for the purpose of pointing them toward careers in science.

In each of the specific suggestions listed below, the symbiotic aspects of the university/national laboratory collaboration are crucial. Whereas a national laboratory is not equipped to handle a large influx of high school and college science students, most universities lack the large-scale research facilities to provide profound research experiences to a large quantity of summer students. That is why the combination of the two institutions can successfully provide the summer programs desired for a large number of students.

I have three suggestions for summer programs involving university and national laboratory cooperation. The first is aimed at talented high school students, the second is for high school science teachers, and the third is for undergraduate science majors. Their common element is that each would involve a program of research and coursework at in a university/national laboratory environment.

A. High School Students

The Department of Energy currently sponsors a fine initiative called the High School Science Honors Program. Each of the 50 states selects seven high school students, one to be placed in each of the seven national laboratories participating in the program. In the program, each of the seven national laboratories has 50 high school students for a two-week program of research experiences. A similar program in the state of Tennessee is the Governor's Schools, the science portion of which is hosted by the University of Tennessee, Knoxville. Approximately 150 Tennessee high school students visit UTK for four weeks of course work and research experiences in the summer.

The strongest elements of both of these programs could be combined to give a lasting experience for many more talented high school science students. The DOE program currently is able to accommodate too few students from each state. An increased number of students involved in the program for a period longer than the presently-offered two weeks would require the use of faculty from the university working with a national lab scientist to handle the increased influx of students. Rather than the national laboratory handling 50 students for two weeks, I propose that the combined national laboratory/university entity accommodate 300 students for six weeks of summer science experiences.

If this expanded program were to be instituted, ample dormitory space on the university campus would be available for the six-week period. Students would spend half of each week at the university and half at the laboratory. At the university, they would be involved in short courses on Fortran programming, astronomy, and biochemistry, in addition to laboratory exercises in biology, chemistry, and physics. At the national laboratory, the students would be involved in research projects. To provide continuity between the two halves of these experiences, it would be wise for some of the national laboratory research supervisors to be university faculty who are involved in those facilities for their own research programs.

Over a five-year period, this program could provide meaningful research experience to 10,500 students (in the limit of all seven national laboratories participating), many of whom otherwise might not pursue scientific careers. Of course, funds would be needed to operate a program of such magnitude, and cost sharing between federal and state resources would be wise. Funds would be needed to pay for (1) dormitory space for the students, (2) partial summer salaries for the scientists and faculty involved, (3) transportation for the students between the university and the national laboratory, and (4) small stipends for the students themselves. The last point is important, because many high school students feel the necessity of having summer jobs to earn money toward their education.

B. College Science Majors

This part of the program would be modeled on the Science Alliance Summer Research Program discussed above. Two hundred college science majors would participate in the summer program for ten weeks. They would be assigned to research groups, either on the university campus or at the national laboratory. While no courses would be given, there should be a series of lectures (two per week) on current items of interest in broad areas of science. As with the high school students, these 200 college students could live in university dormitory space. A stipend of $4,000 would be required for each student. In addition, funds for partial support of summer salaries for involved scientists and faculty would be important. In view of the increased training they have in science compared to the high school students, students at this level would be involved in a significant research project.

C. High School Teachers

This program could be modeled after the successful STRIVE Program currently being operated by the Oak Ridge Associated Universities (partially in collaboration with the University of Tennessee, Knoxville). Fifty high school science teachers would be involved in a ten-week program in the summer. At the university, they would take courses for graduate credit in scientific areas close to those they teach in high school. The credit is important for their professional advancement in their high school teaching careers. They would also be involved in a research experience with a university or national laboratory group. Their scientific background would be more akin to that of the college students (rather than the high school students), in view of their advanced prior training. Indeed, the college students and high school teachers could be assigned to work side by side in various research areas. A stipend of $3,500 for the summer of enrichment is proposed for these high school teachers.

The programs outlined above are definitely ambitious, intended as they are to provide scientific enrichment for 300 high school students, 200 college students, and 50 high school teachers via a university/national laboratory collaboration. This large number of incoming students and teachers would require a major commitment by the university and the national laboratory; the resources and personnel of both institutions would be essential for such a large-scale program. My personal feeling is that such a program is feasible here in Tennessee, involving the University of Tennessee, Knoxville, and the Oak Ridge National Laboratory. I also anticipate that this could be established at other university/laboratory sites.

The size of the program will require a substantial investment of state and government funds. While some may view the cost as too great, I submit that it is a cost that must be borne by a society facing the technological and scientific imperatives that now confront the U.S. Also, it seems inappropriate that the federal agencies supporting education and civilian research and development should be asked to bear the full federal portion of this program. Military R&D obviously benefits tremendously from the scientists and engineers trained by our universities. Therefore, the Department of Defense or the weapons programs in the Department of Energy should be expected to partially bear the cost of this initiative.

The goal of this program is to nurture interest in science. The urgency felt in the wake of SPUTNIK led to tremendous nurturing of scientific interest in the late 1950s. It is difficult to imagine one such event in today's highly technical society that could inspire students to pursue scientific careers to that same degree. I believe that our high schools and colleges are doing well at teaching high-quality science and mathematics courses. Perhaps what is lacking is the confidence on the part of the student to be able to make the huge jump from the "simplicity" of high school physics to the tremendous detail involved in forefront research and/or development in the physical sciences. The proposed summer experiences for high school and college students would offer an exciting and friendly environment that would go a long way toward decreasing this intimidation factor, while also inspiring the student to study science further for the beauty of it. This is what I mean by nurturing the science student.

Ms. **Lloyd**. Thank you very much, Lee.

Has the Science Alliance examined the college of education curriculum to determine if our teachers are being given a strong background in science fields?

Dr. **Riedinger**. Not the Science Alliance precisely, but the university at large has. I guess my feeling is that the colleges of education in our country are beginning to come into the twentieth century as we are about to proceed to the twenty-first century. There needs to be more science courses in the curriculum of a teacher who wants to teach science. Our college of education is headed in that direction.

Ms. **Lloyd**. But they are just not there yet?

Dr. **Riedinger**. Well they have added a fifth year, a fifth year to beef up the science that the teacher will have. I think they need to go further in that direction, but that is my own prejudice I suppose.

Ms. **Lloyd**. I am going to ask several questions that I would like for all of you to respond to. Jon, you responded briefly on the programs that should be provided for the average students. I would like for all three of you to touch on that just a little bit more, programs for the average student, and the age that we should begin interesting our young people in science programs and the programs that are aimed for elementary and secondary education.

And then finally, to elaborate on the role of programs for teachers. Is this the best way to enhance science education on the programs that should be ongoing and not just summer.

Ms. Bardeen, if you would take the microphone and then—since we do not have microphones for each of you, I thought that might be the most practical way.

Ms. **Bardeen**. Okay. First of all, I think the most important target audience is the teacher, because I think through teachers you reach larger numbers of students than a laboratory could possibly hope to accommodate.

I think that our experience would suggest that the most effective teacher to work with is someone who has had some experience, who is relatively well educated in science; that is to say, most science teachers do meet the State certification requirements for science, although some science teachers may have a minimum number of courses, for example in physics or chemistry or physical science. You need to work with someone who has an understanding of science, not the P.E. teacher who is now suddenly teaching science. That teacher needs to go to a strong university program as opposed to a laboratory program.

Ms. **Lloyd**. Would you recommend bringing teachers back for refresher courses?

Ms. **Bardeen**. Yes, that type of thing. The kind of program where you can update their background and at the same time enhance their teaching skills, get them more comfortable with hands-on science, but also get them more comfortable with the topic itself.

We have found it very successful to use the best teachers as teachers of the average teachers. So in our particular case, we use them as staff members. We use them to put together the curriculum, they know who is out there in the real world who is a good presenter for teachers, and we can very often work again in conjunction with the university, with research people, to put together a program that—in which all of the speakers are exciting to teachers, instead of just one or two and then there are the ho-hum ones where they say yeah, but you know, he was talking way up here and I do not know calculus and I could not understand a word he said.

So I think that it is very important to use teachers as a resource in developing the programs.

I would certainly echo what has been said before, in that I think the laboratories need to reach out to teachers of younger students. I think we need to find ways to enhance the pipeline and we will only do that when we reach out to kindergarten, first grade. And at the same time, you have mentioned a lot about girls and women, and I do not think you can make a change there until you reach out to their mothers, because it is their mothers who are going to turn them off to science. When the little girl comes home and she is eight years old and her mother says I cannot do your math homework, you have got to ask Dad, or I do not know what that yucky stuff is you are looking at, it looks like science to me, you have already turned off a girl. So I think that part of the program needs to address the follow-up, the PTA, the getting in touch with the whole community that is a part of our school system. And I think the laboratories have the potential to do that.

Certainly in our discussions with the people in our region, we see a lot of possibilities, and in fact at Fermilab there are all these ideas bubbling up from the technicians, from the engineers, from the scientists and in some sense we are trying to find a way to put them all together and to have a program that is a cohesive whole and at the same time find the resources to keep those ideas alive.

Ms. LLOYD. Jon.

Dr. VEIGEL. Two responses to the question. With respect to training the trainers which I think is the way to go from a leverage point of view, what is missing as far as I am concerned at the teachers at the public school level is it is very difficult for them to gather themselves together in critical masses, to get that support group kinds of activities. And anything we can do that will enhance that I think has got to be beneficial, from working at the school district level—we talk about adopting schools, we ought to be talking about adopting school districts and working with teachers at that level. It may be possible for DOE, for example, to—I would encourage at least the possibility of a national satellite network where what could be beamed to individual schools would be a 50 minute unit on superconductivity from Fermilab or something from Livermore, so that you could have a menu of enrichment possibilities that could go to the school and be taped and be used by the teachers when it suited their particular purpose.

Ms. LLOYD. That is a good point, because elementary teachers do not have to be certified in science education, is that correct?

Dr. VEIGEL. That is my understanding, right.

Ms. LLOYD. So that is the only way we are going to get this level of expertise in our elementary schools.

Dr. VEIGEL. That is right. And while we started about thinking about it part out of a sense of whimsy, we are getting more serious in Oak Ridge about a child care facility that would be between Oak Ridge Associated Universities, Martin Marietta and the whole town, which is high technology in its own right, and looking at child care and getting at the students at that level with respect to setting the foundation for the kinds of science that we are talking about here. Because to return to my first question, I think it is not so much getting the students originally to commit to science, it is to keep them from foreclosing that later opportunity, and the only way they can do that is by staying open to the possibility of continuing to take the math, et cetera.

The final comment I would like to make about teachers is I think one of the resources that is most rapidly decaying in this country are junior college faculty and faculty at liberal arts colleges where there is not a major program of research underway. And it is these people on whom we are depending to train this next generation and when the half-life of knowledge at that level of science and engineering is turning over—is so short now, those people are automatically behind times unless there is some way for them to be kept abreast of things.

Dr. RIEDINGER. I guess I would like to respond to the issue of the students who are not necessarily the cream of the crop, how to reach out to the minority students or whatever. I guess I am not so worried about women in science, I think they respond to the inspiration just as well as male students. For example, in our summer program for college science majors, of the 100 that we brought to campus last summer, to UT and to Oak Ridge, almost half were female students in the sciences, so I think that will come along okay.

Minority programs, we need to have reach-out programs and we are trying to use part of our money for that, to bring minority students to our program, even though their credentials at first look do not really look as impressive as the other students.

And then as far as attracting the average students into science, I guess my feeling is you start with the cream of the crop. Right now our limited summer programs for high school students can only address the cream of the crop. You have got to try to grab those kids first. As you expand the number of slots available for talented high school students, naturally you go down from the cream and start to move toward the average students. And I guess that is the only way I know how to target the average students.

Ms. LLOYD. Thank you. Mr. Schiff.

Mr. SCHIFF. Panel, I just have one subject I would like to bring up, and that is coming from Dr. Riedinger's reference to Sputnik when you were a student, Doctor. I want to mention my older brother was a high school student when Sputnik went up and he is a physicist now too. So I see the similarity. I might add, when I got my degree in political science, he made great fun of that term political science as a misnomer. Funny thing is, he has not made fun of that recently, I do not understand.

Seriously, I serve on another subcommittee of Science, Space and Technology and that is the Space Applications Subcommittee, which oversees NASA and the space program. There is a movement, of course it has been progressive for sometime, to build a manned space station to be followed by manned, human manned trip to Mars. The testimony has been that from a purely scientific analysis point of view, we could do much of that, if not most of that, if not pretty much all of that, what a space station could do and what a trip to Mars could do, with robotics. It is very difficult to justify exactly why do we need to take the risk and the much added expense of creating a human adaptable environment. And one of the arguments given was the existence of humans in space and on a space trip will stimulate an interest in space and science and so forth. And at first I thought well that is a pretty expensive way of doing things. But I am starting to believe now maybe there is something to that.

I wonder if any of you or all of you would comment, and I do not know that it has to be limited to a space station, that just simply is my experience. But I wonder if investing in highly visible projects will make things worthwhile in the sense of stimulating the interest of our best students in science, which is what we are all trying to do. Any comment or observation you have on that, I would appreciate.

Dr. **Veigel**. Just one comment, Congressman. Sometime in the late nineteenth century, the historian—I have forgotten his name—that noted the disappearance of the American frontier and what that had done to the American psyche, I suspect that science and technology represent this century and next century's frontier for us to explore and that there is value, cost-effectiveness aside there is value for that kind of involvement. It would probably be worthwhile if we sent a poet on the next shuttle flight instead of another scientist for the ability to bring some of that experience home to the Nation as a whole.

Dr. **Riedinger**. Or a Congressman.

Dr. **Veigel**. Or a Congressman. A Congressman has been on a space flight already.

Ms. **Bardeen**. I can see that a manned space program or another big science program like the SFC for example, is something that can generate a lot of excitement and enthusiasm. However, it reminds me in some sense of the idea of the super-athlete, of which there are very few in this world, but yet in some sense what we want to do is interest everybody so they will be involved in intramural programs and have good health. And I would hope that we would not consider programs like that at the expense of shall we say good examples in small science, because I think that young people can be equally inspired by having a good experience with someone when they understand what real science is. And by that I mean not what they necessarily get in all of their classrooms, but having opportunities. For example, to come to Fermilab and see that scientists wear Levis, they are not in their office, they scribble all over the blackboard, they have curly hair, some of them are even women. I mean all of those affective things, if you will, can be just as inspiring as the fact that you could go to the moon. Because you see, I am never going to get to the moon, but in fact I could get in the door at Fermilab and have an opportunity to be involved in something that is really exciting.

So if you have to make a choice, if I had to make a choice and I were in your position and I was looking at it purely from the point of view of motivation, I would choose thousands of points of light that are small rather than one large roman candle that would explode in one puff.

Dr. **Riedinger**. I agree that you justify the space station on the science, but if a spin-off can be inspiration of the next generation of kids into science, I think that is a wonderful spin-off, but of course justify it on the basis of the science that you would do.

Mr. **Schiff**. Let me say, it could well be the choice that Ms Bardeen was referring to. I am awfully concerned, for example, about not only the space station, but the superconducting semicolliders, not that I have—not that it has ever done anything to me, you know, I do not have any problem with it individually but when you start looking at the price on it and it sure appears to me it does affect other programs, that creates a dilemma. Nevertheless, it may well—I cannot overlook, especially for my own family background, the impact that the Sputnik program, and it was not even our program, it was the other side's, clearly had on American education. So I do not have all the answers, but I understand what you are all saying and I appreciate it.

Thank you, Madam Chair.

Ms. **Lloyd**. Thank you very much, Mr. Schiff.

Thank you, you have been an excellent panel of witnesses. We have just really uncovered more in this hearing than we even anticipated and you have largely contributed to the success of this hearing. Thank you very much.

We are going to break for lunch right now and we will get back as soon as possible and try to start a little bit before two. Thank you very much. If there are no further comments, the Subcommittee stands in recess.

[Whereupon, at 12:42 p.m., the subcommittee recessed, to reconvene at 1:50 p.m. the same day.]

AFTERNOON SESSION

Ms. **Lloyd**. The Subcommittee will resume our hearing. We are running a little bit late, but we thank all of you for being here. Our third panel begins our information from educators. Dr. Bernard Benson is a member of the Tennessee Academy of Sciences and a faculty member of the University of Tennessee at Chattanooga. Of course, Dr. Ron Cox is Dean of Engineering at the University of Tennessee at Chattanooga. We welcome you distinguished gentlemen and appreciate you being here. Would you begin your testimony?

Panel 3

STATEMENTS OF DR. BERNARD W. BENSON, DIRECTOR OF CENTER FOR ENVIRONMENTAL, ENERGY, SCIENCE EDUCATION, UNIVERSITY OF TENNESSEE, CHATTANOOGA, AND PRESIDENT OF TENNESSEE ACADEMY OF SCIENCES AND DR. RONALD B. COX, DEAN, SCHOOL OF ENGINEERING, UNIVERSITY OF TENNESSEE, CHATTANOOGA

Dr. **Benson**. Thank you.

The forte of the national laboratories——

Ms. **Lloyd**. Excuse me, you may have to bring that microphone a little bit closer.

Dr. **Benson**. The forte of the national laboratories is research and the national laboratories represent an idealized environment for allowing participation in research projects by precollege students and teachers and by undergraduate majors in the sciences. What I would like to do is temper that statement by addressing, at least from my background, the kinds of programs that I am involved in in science education and the kinds of programs that are going on in the State of Tennessee, because I think from that perspective—and especially as I listen to what is going on here today, I find that I am in agreement with most of what has been said, but I do feel that I can add a perspective that might bring bearing on the problem as you see it.

One program I would like to emphasize is the visiting scientist program of the Tennessee Academy of Sciences. Actually now it is administered by Oak Ridge Associated Universities. About four years ago, ORAU took over the administration of this program and it has been operating under that auspice since that time. The program actually has been ongoing for about 15 years. There are about 169—I think the count in the current roster is 169 scientists involved in the visiting scientist program. Interestingly, 23 of those scientists are employed by Oak Ridge National Laboratories.

Now the point that I would like to bring out with regard to this program is that last year there were 66 requests for visits from schools within the State of Tennessee. These are junior high schools and middle schools and primarily high schools. Only 45 of those visits were completed. I am not going to speculate as to what that means, but it clearly is an under-utilized program.

There are several other programs that I do not think have been mentioned, that I will mention briefly and then focus on those that I am directly involved in.

The Junior Science and Humanities Symposium, which has been active for 24 consecutive years under the direction of Dr. Paul Wishert, Professor Emeritus of Science Education at UT-Knoxville. Thirty-five schools participated in this program last year and I believe including the national labs, approximately 20 laboratories provided direct and indirect support for this program.

We have a very active regional science fair program in Tennessee, there are four regional science fairs. I do not believe the Center for Excellence in Science Education at UT-Martin has been mentioned. They have a myriad of programs addressing precollege science teacher education.

And I think I would like for the record to emphasize that two professional organizations in addition to the Tennessee Academy are very actively involved in science education. They are the Science Association of Tennessee and the Tennessee Environmental Education Association. As President of the Tennessee Academy of Science, I am most familiar with the programs that have an educational focus, of this organization.

In addition to the visiting scientist program, the Academy supports a grant-in-aid program administered by the Academy's research committee. This is students in Tennessee's high schools who are eligible to participate in this program. The Academy made 14 awards last year to support research in the fields of science and engineering.

The primary program dealing with research in science education—or research, I am sorry, research in the sciences, directed by the Academy is the Academy's—the Tennessee Academy's Junior Academy of Science. The primary purpose of this is to aid in promoting and encouraging improved science education instructional programs in Tennessee high schools and to encourage more original scientific research by young students under the guidance and instruction of competent and inspired secondary teachers. At the annual meeting of the Tennessee Junior Academy this year, which was held incidentally on April 21 at Pearl Cohn Comprehensive High School in Nashville, a total of 23 students were invited to present papers, 44 papers were submitted from 11 schools.

This morning you heard testimony from Mr. Willis describing the university-based center network that is supported in part by Tennessee Valley Authority. As Director for the Center for Environmental, Energy, Science Education at UTC, I have been involved for the last nine years in this very comprehensive network. Each of the centers in this network provide several basic functions, all of us are involved in providing services and resources through pre-service and in-service teacher education. All I think are involved in working with teachers and promoting teachers in the development of instructional resources and materials. And each of the centers I think is unique and stands out for their particular area of expertise. For example, I work very closely with Tennessee Wesleyan College. Both UTC and Tennessee Wesleyan Centers are involved in the design and development of applications of laserdisc technology to education. Tennessee Wesleyan emphasizes science applications at the college level and we work primarily with elementary and secondary school teachers in exploring ways to use this technology in education, especially science education.

The program that I think has received most recognition that I am involved in is the student water quality monitoring network. This too is a program supported by TVA and in this case primarily the Water Quality Department of TVA. There are some features of this program that I would like to emphasize because it has been considered, at least by those that participate in it, to be the most outstanding program that they have ever participated in concerning their own professional growth and development.

I think there are some special qualities that this program has that result in this kind of statement. I think one point to make is that the program is ongoing, it is now in its fourth year of operation, essentially the same teachers and students have been involved throughout that period. The program has not just focused on disseminating information to teachers, but involving teachers and students actively in research, in this case research on water quality. All teachers are given some instructional background but the emphasis is on developing cooperative relationships between professionals in the field of water quality, educators and students. So there is a mutual relationship, and the key I think to any effective in-service education program for teachers or any effective science education program at the precollege level is a mutual benefit, a benefit that can be derived by both teachers and students.

One thing I would like to focus on is the—some of the reasons why programs like ours are successful or some of the concerns or admonitions that you might want to look at concerning directing precollege teacher education programs in the future.

Science for all Americans, a recent publication presented by AAAS, states that emphasis on science instruction in the schools today is on learning the answers more than on the exploration of questions. Memory at the expense of critical thought, bits and pieces of information instead of understandings in context, recitation over argument and reading in lieu of doing. This account goes on to say that the present science and mathematics curricula are overstuffed and under-nourished. The condition is not likely to change until the governance of science education is controlled by that small percentage of teachers that I mentioned above.

Now if you look just at the involvement of teachers in the Junior Academy of Science, 11 schools out of some 350 secondary schools in the State of Tennessee, that comes out to something like three percent of the teachers are involved. When I talk to colleagues around the State, I find—that are involved in these other programs—that essentially the same teachers are involved in all the programs. So the leadership is very small, and the leadership is very diffuse.

We can focus on a certain program being effective, but if we really look at the interface between these programs, we are finding that maybe we are reaching the same people and that same percentage—that percentage is very small.

I do feel that the national laboratories should play a vital role in science preparation programs, but should restrict their involvement in other aspects of teacher education at the precollege instructional level, such as in the development of instructional products or in preparation of teachers in general.

Central to the problem of developing scientific literacy at all levels is the development of effective elementary school science teacher education programs. Little more than titular support has been given to college and universities in recent years to develop more teacher education programs. The increased involvement of national laboratories in these areas, unless done cooperatively with higher education, can only result in a dilution of effort and distortion of what really needs to be done, and I think this statement has already been echoed several times this morning.

I know that my remarks do not fully reflect the complexity of the dilemma facing us in science education today. Nor have I expressed the perplexity I feel when trying to communicate my views on the problem. I am a strong advocate of a soft path approach to most problems in education; that is, a lot of small efforts as opposed to a few larger ones. Whatever we do, the personal and professional growth of students and teachers is central to our mission. What we do not need are more programs that reflect the defect point of view, and that is that there is something wrong with the teachers out there and the experts in the field know what the answer is. That is the hard path approach, it has not worked in the past and I do not think it will work now.

Thank you.

[The prepared statement of Dr. Benson follows:]

Science, Mathematics, and Engineering Education Programs and the Role of Our National Laboratories in Science Education

Testimony Presented to the Subcommittee on Energy Research and Development

by

Bernard W. Benson, Ph.D

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Chattanooga, Tennessee

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Introduction

It is my understanding that the purpose of this hearing is to explore options for increasing the involvement of our National Laboratories in pre-college science education for the purpose of "exciting students and encouraging them to enter" careers related to science and technology. This is a laudable goal and I unequivocally support its intent. The forte of the National Laboratories is research, and the National Laboratories represent an idealized environment for allowing participation in research projects by pre-college teachers and students as well as undergraduate students majoring in teacher education.

Existing Programs

I would like to present an overview of what is already going on in this area, at least from a Tennessee perspective, before addressing the question of what should come next. It is my understanding that the Oak Ridge National Laboratory has several ongoing programs and new initiatives that range from awareness projects to the direct involvement of students and teachers in research activities.

The Oak Ridge Associated Universities has received National Science Foundation funding to support research participation. For the last four years ORAU has also administrated the Visiting Scientist Program of the Tennessee Academy of Science. Upon request, these scientists give talks and demonstrations in their areas of expertise before junior high and high school science groups. During the 1987-88 academic year there were 61 visits requested, of which 45 were completed. One hundred and seventy scientists were on the roster that year. This program has been an ongoing effort of the TAS for over 15 years. I had the pleasure of directing this program for several years and can attest to the dedication and support of the program by scientists in Tennessee. I should note that 23 of the 169 scientists listed in the current roster are employed by ORNL.

The Junior Science and Humanities Symposium has been active for 24 consecutive years. Thirty-five schools now participate in this program directed by Dr. Paul Wishart, Professor Emeritus at UT-Knoxville. He reports a high level of cooperation between the U.S. Army Research Office, ORAU, ORNL, and private industries including Union Carbide and Martin Marietta. Approximately 20 laboratories provide direct and indirect assistance to students in their respective research projects.

Tennessee is also actively involved in the Regional Engineering and Science Fair program, the Science Olympiad, and a wide range of programs offered through the Center for Excellence in Science Education at UT-Martin. The Science Association of Tennessee and the Tennessee Environmental Education Association are two viable organizations with active programs in support of science education.

As President of the Tennessee Academy of Science, I am most familiar with the educational programs of this organization which are financially supported by the Tennessee Department of Education, the American Association for the Advancement of Science, and the Alcoa Foundation. TAS has been in existence for 76 years and will hold its 100th meeting on the UT-Chattanooga campus in 1990. This organization has over 900 members representing the state's secondary schools, colleges and universities, industrial scientists, and state and federal agencies. There are nine sections in the Academy, including botany, chemistry, engineering, math and computer science, medicine and zoology. In addition to the Visiting Scientist Program, the Academy publishes a scientific journal, organizes annual scientific meetings, provides recognition to outstanding science teachers, participates in the American Association for the Advancement of Science, supports research by Tennessee's university students at the Academy's collegiate division, provides for secondary school student research, and sponsors a junior academy of science. The latter two programs have direct bearing on the issue at hand.

Grant-in-aid for research is administered through the Academy's research committee. During the 1987-88 fiscal year, the Academy received sixteen applications requesting a total of $5,182 for science projects from secondary school students. The Academy made fourteen awards in the amount of $1,854. Linda Corn of Haywood High School was awarded $125 to support here project entitled, "Removal of Pollutants by Household Plants." She won three awards at the 1987 International Science and Engineering Fair in San Juan. She also won the first award at the Midwestern Research Institute and received an honorable mention from the Federal Aviation Administration. This year this program will have an operating budget of $3,000, which includes $1,000 requested from AAAS.

The overall objective of TAS's Tennessee Junior Academy of Science is to aid in promoting and encouraging an improved science instructional program in Tennessee high schools and to encourage more original scientific research by young students under the guidance and instruction of competent and inspired secondary teachers. The annual meeting of TJAS was held on April 21 of this year at Pearl Cohn Comprehensive High School in Nashville. A total of twenty-three students were invited to present their research papers. Forty-four papers were submitted this year from eleven schools.

I think you will agree that these efforts are impressive and represent a significant attempt to improve the quality of pre-college science education. Before addressing the matter of effectiveness, I would like to note that what I have described so far represents only a portion of the science education initiative in our region. Each of the public colleges and universities in this area have ongoing pre-service and in-service science education programs.

Environmental/Energy/Science Education Network

Noteworthy are the efforts of some 13 colleges and universities which comprise the Environmental, Energy, and Science Education Network coordinated through the Environmental/Energy Education Program of the Tennessee Valley Authority. This Network is in its ninth year of operation. I serve as director of the center at UT Chattanooga. You will be given a detailed account of the activities of the Network at another time in this hearing, but I would like to emphasize some of the special programs of our center from the standpoint of identifying qualities of such programs that assure their effectiveness. It is important that these qualities be incorporated into similar involvements by the National Laboratories.

All the centers in the Network provide resources and services to the schools, teachers, and students in their respective service areas. We are actively involved in pre-service and in-service teacher education. All play an active role in involving teachers in the development of instructional products and curricular materials, and each is involved in research focused on the development of some aspect of scientific or environmental literacy. Each of the centers is unique and is recognized for its special areas of expertise. For example, the centers and UT Chattanooga and Tennessee Wesleyan College work cooperatively in the area of the applications of laser disc technology to education. TWC has stressed applications for college level science instruction and the UT Chattanooga Center focuses on pre-college applications.

For any program to be effective there must be continuity, coordination, and cooperation. Our programs are administered through our respective universities and cooperatives but the programs and services we offer are credited to the Network. We function through mutualism--shared responsibility and shared recognition. Most importantly, the practitioners and students become involved in the activities of the centers. They are not only on the receiving end of services, they are part of the overall network and share in both the responsibility and the rewards.

By far the most recognized program administered through UT Chattanooga is the Student Water Quality Monitoring Network, now completing its forth year of operation. It is supported by TVA's Water Quality Department through a contract to UTC and includes support from TVA's Environmental/Energy Education Program. All the centers in the Network are involved in recruiting teachers and students into this program. Staff from the centers regularly participate in the training workshops and summer water camps.

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The program was begun in 1986 with the dual objectives of incorporating water management concepts into the secondary school curriculum and developing basic water quality data on small streams and lakes in the Tennessee valley. The program has grown from a base of 10 teachers and 22 students in 1986-87 to a network of 30 teachers and 46 students involved in detailed field studies and some 4000 students who participate in classroom and field activities associated with the program.

Students and teachers attend two-day workshops in the early fall and receive both classroom instruction and field training. The workshops include discussions in the differences in streams, lakes, and reservoirs; water quality management programs developed in response to state and federal water laws; the quality of water required for various water uses; conflicts associated with managing flows through a system of reservoirs; and practical considerations in designing field studies. Field training includes hands-on experience in using a water quality test kit provided to participating teachers, invertebrate sampling, and fish collection techniques.

Upon returning to their schools, the teachers and students develop new instructional materials on water resources and incorporate the concepts learned at the workshop into the existing curriculum. They also design and conduct field studies on local streams or lakes and prepare a report on these studies. Papers and poster sessions are presented at water camp which is scheduled in early summer where additional lecture and field instruction involve the concepts and skills learned the previous fall. Teachers are also provided funding to present papers at professional meetings and conferences. A yearbook will soon be added to the annual features of the program. Last year a senior associate program was instituted to ensure that the teachers in the network continue to contribute and grow professionally as a result of their continued participation.

Numerous awards and scholarships have been received by WQMN teachers and students. Two teachers have confided in me that they would have quit the teaching profession had it not been for this program. This program is consistently rated as the most effective in-service program in which the participants have been involved. There are some obvious reasons why this is so. First, teachers are treated as colleagues and professionals. There is a close professional and personal relationship between staff, teachers and students. Indeed, we often trade roles. We learn from one another. Teachers become students and students teachers. The lines of communication are always open. Teachers and students are free to call professional water quality engineers to discuss their field studies or seek technical assistance. The research conducted by the students and teachers relates to the real world. Indeed the studies conducted contribute to TVA's database and serve to identify potential problem areas. All aspects of the Network centers around a Science/Technology/Society focus. The program is relevant, the participants are recognized for their efforts, and the rewards are shared and memories cherished.

We are concerned with the personal growth of the individuals involved. The transition to careers in the sciences, social sciences, mathematics, or engineering will occur for many of the students involved. What is more important is that they become scientifically literate. *Science for All Americans--Project 2061*, a recent publication of AAAS states that, "a scientifically literate person is one who is aware that science, mathematics, and technology are interdependent human enterprises with strengths and limitations; . . . and uses scientific knowledge and scientific ways of thinking for individual and social purposes."

Recommendations

A reasonable question to ask is, with all this activity, why are there so few students entering the fields of science, math, and engineering? Part of the answer to this question is inherent in what I have presented above. Note that TAS received only 16 applications last year for its secondary student research program and there were only 44 papers submitted to the Tennessee Junior Academy of Science from 11 schools. That means that approximately 3 percent of the secondary schools in Tennessee participant in the TJAS program. It is also interesting that when comparing notes with other project directors, we find that the same teachers seem to be involved in many of the programs. There are indeed a few select, highly motivated, productive, and effective science teachers in Tennessee, but many are disinterested, disaffected, or disillusioned. Whatever the reason, they are not involved and neither are their students.

The practice of hiring coaches who, in turn, can teach science is still a common practice, although I will hasten to note that there are many excellent science teachers who also coach. There is often a preoccupation with accountability and the teaching of basics which seldom includes more that a cursory coverage of science. *Project 1061* notes that the emphasis on science instruction is on the learning of answers more than on the exploration of questions, memory at the expense of critical thought, bits and pieces of information instead of understandings in context, recitation over argument, reading in lieu of doing. This account goes on to say that the present science and mathematics curricula are overstuffed and undernourished. This condition is not likely to change until the governance of science education is controlled by that small percentage of involved teachers mentioned above.

I would also encourage a broader network than the TVA Network. Also research participation or collaborative programs are not the exclusive purview of the National Laboratories. For example, the research interests of the Tennessee Academy's collegiate members vary from the pure research of Dr. Savundararaj of Vanderbilt University, who studies ion bombardment of surfaces, to the applied work of R. D. Blevens and S. V. Char of East Tennessee State University, who determine the mutagenicity of the active ingredients present in birth control pills. In recent years, trends in the job market have enabled our institutions of higher learning to recruit and maintain highly qualified teachers and researchers. Most would welcome increased association with teachers and pre-college students.

The National Laboratories should play a vital role in such research participation programs but should restrict their involvement in other aspects of teacher education or pre-college instructional product development to cooperative efforts with higher education institutions.

Central to the problem of developing scientific literacy at all levels is the development of effective elementary school science programs. Little more thantitular support has been given to colleges and universities in recent years to develop more effective teacher education programs and to recruit and maintain adequate staff. The increased involvement of the National Laboratories in these areas unless done cooperatively with higher education can only result in a dilution of effort and a distortion of what really needs to be done.

I know that my remarks do not fully reflect the complexity of the dilemma facing us in science education education today. Nor have I expressed the perplexity I feel when trying to communicate my views on the problem. I am a strong advocate of a soft path approach to most problems in education, i.e., a lot of small efforts as opposed to a few larger ones. Whatever we do, the personal and professional growth of students and teachers is central to our mission. What we do not need is more programs that reflect the defect point of view--there is something wrong with what science teachers are doing and we can solve the problem. That's the hard path approach. It has not worked in the past nor will it work now.

Ms. LLOYD. Thank you very much. Dr. Cox.

STATEMENT OF DR. RONALD B. COX

Dr. COX. Thank you. I appreciate the opportunity to be here today and to share some ideas with you concerning not only programs which are in existence, but some views that I hold, opinions which I hold regarding the critical nature of education within engineering and the science areas. I would like to share comments particularly regarding engineering, engineering education and related research activities.

First, in a broad sense, I believe it is generally agreed that our country is becoming more dependent upon technology. The facility with which we conceive ideas for new products and processes, and convert these ideas into real products and processes which compete effectively in world markets will be a major factor in our quality of life in the future. In a sense, our survival depends upon our success.

The combined activities of science and engineering lie at the very heart of our Nation's technological vitality. The skills important to technology management simply must be both cultivated and nurtured if our Nation is to be secure and if it is to compete effectively with others in the commercial arena.

To address these concerns, I believe that several things must occur:

1. We must do a better job of exposing our young students to the world of engineering and science.

2. We must do a better job of preparing students to solve problems, to formulate problems and to apply analytical skills to their solution.

3. We must attract more students to the study of engineering and science.

4. We must do a better job in engineering schools of introducing students to the integration and synthesizing of knowledge.

5. And we must do a better job as practitioners, as engineers, as manufacturers, of turning ideas into useful products and processes that will compete effectively in the marketplace.

The list of things we might do could be much longer; however, I shall let this list suffice for our brief discussion today.

Please allow me to comment briefly on some of these matters.

In order to cultivate the skills we need, we must begin exposing students to the world of technology when they are in elementary school. To wait until they are students at the university is simply too late. This means that students should be given laboratory experiences as well as improved math and science courses. The natural curiosity of our young people must be enhanced by the educational experience, and the teachers, counselors and administrators must become keenly aware of what science and engineering involve, and they must work to develop the skills of problem solving and basic inquiry which are so important both to the study and to the practice of engineering and science.

By conquering the fear of engineering and science, both through confidence building and competence building in the early years of our schooling of our young people, I believe that we will see enrollments increase and the success rates of our students improve.

On the university level, we can be proud of our accomplishments in at least one area, in the area of generating new concepts and ideas. I believe that most people would agree that the research done in our universities is the best in the world. As a Nation, we have had problems though in our ability to convert and to convert quickly these ideas into useful products and processes. I believe there are many reasons for this. Among these are the inadequate flow of information from the laboratories to the producers, short time horizons imposed by investors, tax policies which may inhibit investment in development and too little emphasis in engineering schools on the process of converting ideas to products and processes.

Let me comment on the latter topic first. All engineering schools emphasize the development of analytical skills, among many other skills. Also, all engineering schools teach basic design to engineering students. However, few schools do a good job of preparing engineering students to synthesize and to integrate information which most often cuts across many disciplines. I believe that more emphasis needs to be given to this matter. Fortunately, if I may brag on our engineering program at UT-Chattanooga, I think we are at least on the right track in our engineering school. We emphasize interdisciplinary design projects which allow students to work in teams to address comprehensive problems. In this way, students learn to manage large-scale projects, to work effectively with others, to manage resources, to design and test systems and subsystems, and to make timely decisions. These are important skills to cultivate. In my opinion, however, there should be funds made available to schools who approach engineering education in this way. There needs to be a funding agency that will address this critical need among our engineering students.

If I might digress just a moment from the prepared comments, I would say that there is in essence a two-tiered funding system among engineering schools across the Nation. One tier has to do with the large research universities, comprehensive research institutions, which are largely funded by government agencies and many industries. The other group, the group which provides at least one half of our engineering graduates in this country, are not comprehensive research institutions. They receive very little Federal funding. However, they are still producing about half of the graduates that move into our companies, into our industries and into our Federal agencies. There must be attention given to those areas that can provide satisfactory experience to the half of our total 70,000 plus engineering graduates per year, to give them experiences in areas which involve up to date and modern laboratory equipment, which expose them to state of the art research developments and which bring them to the contact point, if you will, with people who are engaged in important technological developments in this country. Without this attention, I am afraid that this some 35,000 plus engineering students per year will enter the work force without the necessary skills to address the problems that they must face.

An extremely important element to the enhancement of engineering and science education is the opportunity to work with national laboratories. These enhancements come in many forms and include at least these:

1. The possibility of direct research funding by the agency to a university, allowing students to engage in important research work and to work with people who are at the cutting edge.
2. Collaborative discussions between folks in the laboratories, engineering and science faculty members and students. These discussions of course bring out important technological issues, they bring out ways of addressing these issues and the technology that is brought to bear on problems that must be dealt with if we are to remain competitive in this country.
3. Research engineers and scientists come together to speak to student groups. That is, visitation to the universities and colleges around the state and around the country, sharing with them those issues that are important to the laboratories and discussing ways in which those issues are being addressed.
4. Additionally, agencies may employ students, these students may be engineering students or they may be science students or others. One common way of doing that is through cooperative educational programs. These programs are excellent avenues for providing experience to students and providing trained talent for the industries and agencies for whom they work.
5. Also there may be agreements with an agency which will provide agency laboratory equipment. Specialty equipment which could not be afforded by universities and colleges can be made available to faculty members and students on a variety of bases which may allow then critical work to be done at a university which would not otherwise be done, simply because of lack of necessary equipment.
6. Also there may be sharing of discoveries. These discoveries may very well lead to the commercialization of products and processes. There must be ways to improve the sharing of this information, information of course which is not critical to the security of the nation but information which may very well inspire some group or some individual to develop and important product or process which can be commercialized, leading to the formation of a company and to the employment of many people.

We feel fortunate at the University of Tennessee at Chattanooga to have had an excellent working relationship with the Tennessee Valley Authority, the Oak Ridge National Laboratory and NASA, and we look forward to the continued development of partnerships with these and other agencies as we move forward into the future. All of the items which I have elaborated a moment ago have been cultivated through these kind of relationships with these organizations. And I may add they have reached hundreds of people and we feel fortunate to have been a participant in these partnership relationships.

Our Nation has a wealth of talent, this talent is found among teachers, engineers, scientists, students and people in all walks of life. Our challenge is not simply to find talent, the talent is there; the challenge is to manage our resources as effectively as possible. But to do this will require considerable cooperation, considerable coordination and doing things in ways that we have not been doing them before.

I think we can do that and I thank you for being in Chattanooga today and for expressing interest in these important matters surrounding technology development and application.

Thank you.

[The prepared statement of Dr. Cox follows:]

Comments to the Subcommittee on Energy Research and Development (Marilyn Lloyd, Chairman)

Submitted by: Ronald B. Cox
Dean, School of Engineering
The University of Tennessee,
Chattanooga

Date: May 15, 1989

Comments to the Subcommittee on Energy Research and Development

Submitted by Ronald B. Cox

My name is Ronald B. Cox. I am dean of the School of Engineering at The University of Tennessee at Chattanooga.

I appreciate the opportunity to appear before the Subcommittee on Energy Research and Development and to share some views with you regarding engineering, engineering education, and related research activities.

First, in a broad sense, I believe it is generally agreed that our country is becoming more dependent upon technology. The facility with which we conceive ideas for new products and processes, and convert these ideas into real products and processes which compete effectively in world markets will be a major factor in our quality of life in the future.

The combined activities of science and engineering lie at the heart of our nation's technological vitality. The skills important to technology management simply must be both cultivated and nurtured if our nation is to be secure and if it is to compete effectively with others in the commercial arena.

To address these concerns, I believe that several things must occur:

1. We must do a better job of exposing our young students to the world of engineering and science,
2. We must do a better job of preparing students to solve problems - to formulate problems and to apply analytical skills to their solution,
3. We must attract more students to the study of engineering and science,
4. We must do a better job, in engineering schools, of introducing students to the integration and synthesizing of knowledge, and

5. We must do a better job, as practitioners, of turning ideas into useful products and processes that will compete effectively in the marketplace.

The list of things we might do could be much longer; however, I shall let this list suffice for our brief discussion today.

Please allow me to comment briefly on some of these matters.

In order to cultivate the skills needed, we must begin exposing students to the world of technology when they are in elementary school. This means that students should be given laboratory experiences as well as improved mathematics and basic science courses. The natural curiosity of our young people must be enhanced by the educational experience, and the teachers, counselors, and administrators must become keenly aware of what science and engineering involve, and they must work to develop the skills of problem solving and basic inquiry which are so important both to the study and practice of engineering and science.

By conquering the fear of engineering and science both through confidence building and competence building exercises in the early school years, I believe that enrollments will increase and that success rates will improve.

On the university level, we can be proud of our accomplishments in generating new concepts and ideas. I believe that most people would agree that the research done in our universities is the best in the world. As a nation, we have had problems, though, in our ability to convert (quickly) these ideas into useful products and processes. I believe that there are many reasons for this. Among these are the inadequate flow of information from the laboratories to producers, short-term time horizons imposed by investors, tax policies which may inhibit investment in development and too little emphasis in engineering schools on the process of converting ideas to products and processes.

Let me comment on the latter topic first. All engineering schools emphasize the development of analytical skills (among other things). Also, engineering schools teach basic design to engineering students; however, few schools do a good job of preparing engineering students to synthesize and integrate information which most often cuts across many disciplines. I believe that more emphasis needs to be given to this matter. Fortunately, if I may brag on the engineering design program at The University of Tennessee at Chattanooga, I think we are on the right track in our engineering school. We emphasize interdisciplinary design projects which allow students to work in teams to address comprehensive problems. In this way, students learn to manage large-scale projects, to work effectively with others, to manage resources, to design and test systems and sub-systems, and to make timely decisions. These are important skills to cultivate. In my opinion, there should be funds made available to schools to develop this approach to engineering education.

An extremely important element to the enhancement of engineering and science education is the opportunity to work with national laboratories. These enhancements come in many forms and include:

1. direct research funding by the agency,
2. collaborative discussions on important technological issues,
3. research engineers and scientists speaking to student groups,
4. agencies employing cooperative engineering students (or co-op students in general),
5. agreements with an agency to use selected laboratory equipment, and
6. sharing of discoveries which may lead to the commercialization of products or processes.

We are fortunate at The University of Tennessee at Chattanooga to have an excellent working relationship with the Tennessee Valley Authority, the Oak Ridge National Laboratory, and NASA and we look forward to developing partnerships with these agencies, and others, which will be beneficial to all groups.

Our nation has a wealth of talent among our people - teachers, engineers, scientists, students, and others. Our challenge is to manage our resources as effectively as possible. This will require considerable cooperation and coordination.

Finally, let me thank you for being in Chattanooga today and for expressing interest in these important matters surrounding technology development and application.

Ms. **Lloyd**. Thank you very much, Ron, Dr. Benson. I want to go back to one of your opening statements, Dr. Benson, when you were referring to the visiting scientist program. You are a visiting scientist. You said there were 66 requests for visits and 45 were completed and most of the scientists were from the Oak Ridge National Laboratory, is that correct?

Dr. **Benson**. There are 169 scientists listed on the roster.

Ms. **Lloyd**. All right.

Dr. **Benson**. Of the 169, I believe about 23 are employed as scientists at Oak Ridge National Laboratory.

Ms. **Lloyd**. Pardon me, I missed—I wanted to get that correct for the record.

Dr. **Benson**. By far the largest share of scientists represent public and private universities in the state. This has been an ongoing program. I directed it for several years and it was also directed by Dr. Wishert at Knoxville. I would say that it has been operational continuously for the last 15 years or better.

Ms. **Lloyd**. Well, certainly we need to expand on this program and make it certainly a more productive program. Why did we have 45 completed visits and 66 requests for visits?

Dr. **Benson**. A lot of times it is logistically impossible to honor a request, a scientist might have a prior commitment or another commitment, the school requesting the visit possibly does not have an alternate, they want one person and if that person cannot come, they do not want anyone else. My concern with the program, and I do not know the answer, is why is it not utilized more than it is. It certainly represents a wealth of expertise.

Ms. **Lloyd**. To me, there is a wealth of talent there. We were talking in the hearings this morning about most of our elementary teachers, where we really need to be emphasizing the importance and training more minds, and certainly developing the inquisitive mind, that most of the teachers in this area are not qualified science teachers in many areas. Certainly we need more visiting teacher programs, visiting scientist programs and taking the wealth of talent at our national laboratories, for instance, in the VCR's that come in the area, and train through this method. But we do know that the schools cannot raise the scientific literacy of this Nation alone, it is going to take our combined efforts to make this a reality.

Dr. **Benson**. I think you can classify efforts based on the potential they have, and a program like the visiting scientist program is probably at the lowest level of effectiveness because it deals exclusively with awareness. It might excite students, it might develop a sense of breadth about the context of what a particular person is doing in the sciences, but it is purely at the awareness level. You are there for a day and you may never return. And it may have lasting impact, hopefully it will, on some students, it may make an impression, but programs like that should be viewed in perspective in terms of what potential they have.

Programs that I think have a much greater effectiveness are those that deal with the effective qualities of the teacher, especially as a professional. One thing we do in the water quality network is provide funds for teachers to participate in professional meetings. They present the results of their research and their curriculum development projects at professional meetings. These meetings may be science teacher meetings or they may be science meetings dealing with water quality, like the national association dealing with water quality research. And that—over a long period of time, teachers involved in programs like that, realize that they are professional because they are treated professionally. I have had two teachers, I mentioned in my testimony, that have confided in me that had it not been for that program, they would no longer be in the teaching profession. Typically school systems do not provide the kinds of resources needed to involve teachers in that kind of extended professionalism.

Ms. LLOYD. One of the questions we asked the morning panel, if you had more money to put in science education, where would you put it, and I think the general consensus is that they would spend it on enhancing the quality of education for our teachers. Would you agree or would you put it in the elementary level?

Dr. BENSON. Well, let us look at it a little differently. I would look at it in terms of organizationally where the money would be put and I think organizationally it should be primarily placed in organizations that are governed by teachers. Effective teacher governance is the key to effective education. There are very effective teachers in this country who are teaching science. Typically they have very little voice in what goes on. So I would look at organizations like the Science Association of Tennessee or the National Science Teachers Association or the other organizations I mentioned, and I would focus initially efforts in those areas. And the other spin-off of that is that these are much more cost-effective because they are operated primarily by teachers as a professional activity, and they would be much more cost effective than putting significant amounts of money into very large bureaucracies.

My point in stating that I believe in programs that are soft path related as opposed to hard path is that several smaller efforts—we need a lot of windmills out there dealing with—promoting the quality education, and teachers that are effective are the ones that should be making the decisions. Often educational decisions are made by people who do not have the expertise to make them.

Ms. LLOYD. We are approaching this though as a national policy to heighten awareness of the importance of science and engineering and that science is to be considered a basic skill. In that direction, that it does have to have the Federal involvement, that we do establish this as a priority and work to create the scientists and engineers we need not only in the workplace but for the defense establishment as well, it seems to me we do need greater collaboration with the labs and universities.

Dr. BENSON. May I look at this issue from a different perspective? We—even I think at the heyday of NSF involvement in precollege teacher education, the level of effectiveness was relatively low, because at that point—I mentioned the defect point of view, and incidentally programs in that era were based on this defect point of view, that people involved in higher education and scientists thought they knew how to train teachers.

But I think what we have never really done is address the needs of students who are extremely capable but simply are not school smart. We focus on programs that emphasize the analytical aspects of learning rather than on motivational aspects, rather than on common sense applications, or rather than on the dynamic approaches to self-learning that many students are capable of doing if given the direction and initiative. That the focus on over-stuffed and under-nourished can relate to many aspects of education. We are doing an awful lot of things, but I am not sure if we are doing the right things. And my question to your Subcommittee is what constitutes doing the right things. And I think part of the answer to that is involving more teachers in the decision-making process. You know, the important people here I think are the ones that are going to present testimony last, because they are the ones that have credibility and they are the ones that will serve as the leadership for directing science education in the future.

Ms. LLOYD. Your point is well taken. As I said earlier, we are not here to put down the education establishment. We are here to see what we can do to help.

Dr. BENSON. I am not either because I am part of that establishment, and I think I have always——

Ms. LLOYD. I wanted to make that very clear.

Dr. BENSON. I understand.

Ms. LLOYD. That is not our role today. We want to see what we can do to enhance science and engineering and education because we cannot afford mistakes. The wealth of our country, the security of our country depends on the decisions we will make when we know that our scientists and engineers for the next decade are in your schools today or in elementary schools.

Dr. BENSON. There were two dates mentioned this morning, 1957 was one, the Sputnik era, and then again in 1965 and the mention of a resurgence of interest in science education today, and I think that phenomena, that cyclic nature of interest, is part of the problem. And I do not think we can eliminate the cyclic nature of interest, but I think we can increase the threshold level. I think we can increase the base of support so that we do not have such serious, serious discrepancies in quality. If we can maintain a higher base of support, then I think part of the problem will be solved. But I think the other aspect really is dealing with approaches to learning that go beyond analytical aspects. And the problem—most people with science backgrounds have a tendency to be analytical. So if you ask primarily scientists what are needed in education, typically they will say more science. And I think if you ask teachers, they will say something else. It is not the amount of science that is important, it is the relevance of that science in the context of what students need to address real world problems. Science, technology and society based problems.

Ms. LLOYD. Your testimony is certainly valuable and we certainly appreciate your input. I am using too much of the time I am afraid, but your insight is so great I went on a little bit past my time.

Dr. Cox, you referred to interaction between the Oak Ridge National Laboratory and UTC. I would like for you to elaborate a little bit on the interaction, what you see as—what we could do that we are not doing, where do you think we are going.

Dr. COX. I did mention the interaction between UTC and the Oak Ridge National Laboratory. I should also mention, which I did mention very briefly, interaction between UTC and TVA as well as between UTC and NASA. If I could lump all of those together, it might make my answer a bit easier.

That interaction has been extremely beneficial to the development of the engineering school at the University. And it comes in several ways. One, if I might just take a hypothetical path and trace through it very quickly, if there is a project that is of interest, let us say, to the Oak Ridge Laboratory or to TVA, it may be an energy technology, it may be ways that coal might be burned more effectively. The identification of that problem and then the collaboration among those at the agency and faculty at the University normally results in a project being funded. That project then is undertaken as a study which may cover six months, it may take two years. In the process of that investigation, the faculty members develop an area of expertise beyond where they were at the time that project started, typically. In addition, there may be three or half a dozen students who become involved with that project. Without such funding, you would not involved those students in those kinds of activities, so you are stimulating the interest of students in important technological problems and progress through that interaction. In addition, there may very well have been equipment purchased in the course of that study. That equipment now is used in that laboratory, which aids not only in that particular investigation, but also may be used in classroom exercises. So it enhances the laboratory for use by every student in the University that might come in contact with a course requiring that laboratory.

The very fact that you have the expertise developed among the faculty and the students leads to discussion with other students, perhaps those who are considering coming to the institution, who may be wondering whether or not they are interested in studying engineering or not. Because of that project you may enhance and enlighten and attract new students to the University, who might not have otherwise chosen engineering as a program of study. So the process then becomes repeated. And the more of that kind of interaction you have between the laboratories and the universities, the greater the enhancement for those opportunities to improve the understanding of faculty members toward the technology, to enhance the experiences of students involved and to attract new students.

Ms. LLOYD. I think you were present at a meeting I had recently of the community leaders from Oak Ridge and Chattanooga, and one of my goals is to create a greater—foster a greater relationship between the two communities. What can we do—offhand, what would you suggest primarily, to create greater interaction, not only for education but for economic opportunity?

Dr. COX. There needs to be focal points on both sides. There needs to be a point of contact at the University and a point of contact at the Laboratory, which will enhance the flow of information back and forth between the two. That is one thing. In addition, if there are opportunities for funding of certain type projects, and I would like to fold that into a comment I made earlier, if it happens to be an institution which is referred to as a non-research institution or a non-comprehensive institution, there needs to be consideration given to the capability of faculty members that exist in that institution to conduct research, and important research. For them to do that though, they must have reasonable access to equipment, either access to or equipment in the laboratory. So equipment might be purchased through grants or there might be a sharing relationship between a university and a national laboratory, which will allow faculty members to use equipment at the site of the national laboratory. That enhances research opportunities. Those kinds of things would help.

Ms. Lloyd. Thank you very much. Mr. Schiff, I apologize for taking too much of the time this morning. I will give you equal opportunity.

Mr. Schiff. Actually, Madam Chair, since these are your constituents and your district and you know them quite well, I certainly do not begrudge the time. Actually I have just one question to ask. I have to first say, gentlemen, I apologize for coming in late during your testimony, but I did receive copies of your prepared statement before and did look at them, I want you to know that.

There is actually—in view of Mrs. Lloyd's questions, I have just one question. Dr. Cox, you mentioned all of Oak Ridge National Laboratory, Tennessee Valley Authority and NASA in terms of working with the University of Tennessee. There are two ways, however, of working together. One way can be where these various Federal facilities basically say within our own limitations, within funding within our own primary duties we will help you all we can, whether it is providing utilization of personnel or providing use of our facilities or surplus equipment or whatever. And then there is the mentality of well we will do what we absolutely have to do, kicking and screaming, but we really do not want to be bothered.

In your estimation, has the association with the Federal facilities you have mentioned, has it been on the former, has the cooperation been forthcoming, has it been in your opinion genuine and really interested or has it been we would really rather not be bothered, we will do just what we have to do. Naturally, I hope it is the former, but I am asking your opinion.

Dr. Cox. Well, I think it is the former. We have had excellent success in working, particularly with the Tennessee Valley Authority over the years. And one reason for that is we happen to be in the same city, we happen to have faculty members who are former TVA employees and we have had a good relationship for a long period of time. That has provided access to people who are engaged in managing projects and access to people who are willing to share with us information that may lead to funded research opportunities.

It is not always easy, however. There are many occasions I guess to which I could point which have been disappointments, so it is not a perfect path to getting what you might think you would like to do, but it certainly has been one which has enhanced our educational experience for students here in the Chattanooga area.

Mr. Schiff. Dr. Benson, do you desire to add anything to that question?

Dr. Benson. I guess I have one admonition in that the focus—if you are an engineer, the focus can be on doing things that attract Federal dollars. If you deal with some very insignificant microbe that has little applied value, the struggle for dollars to promote your research might be a lot more difficult. We talked about the involvement of students in research and the involvement of teachers in research, and I think that is a vital part of any science teacher or scientist's experience in their formative stages, in the development of their programs, and what I think, I hope the Subcommittee does not overlook is the very broad based scientific manpower base in the smaller colleges and universities and junior colleges. I know in Tennessee there are—I know one person at Jackson State Community College who does work at the national lab in the summer, and he is involved in a very interesting project. But teachers or professors or researchers in the smaller colleges and universities can certainly work effectively with students and with teachers. In some cases the kinds of things they are doing may be better examples of what research is than some of the more sophisticated and elaborate programs that may be available at the national labs or at our larger universities.

So my only comment is that I think because of the situation that has existed in the past decade or so, we have been able to recruit and maintain in smaller colleges and universities, a very high caliber science personnel and they only need opportunities and some resources to do a more effective job.

Mr. SCHIFF. Well, I am going to take the liberty of reiterating a short speech from the last panel, and that is that I would not begrudge a Federal institution their primary goal, we assign them certain tasks, whatever those tasks might be. At Sandia National Laboratory in my district, frankly that task is primarily a participant in the nuclear weapons program, 90 percent—weapons total, not only nuclear, is 90 percent of what they do. But I have a very strong feeling that we are all in this together and that that attitude should be manifest so that if there is a contribution that can be made from a federally funded institution, whether it is NASA or TVA or Oak Ridge National Laboratory or Sandia National Laboratory, to the educational process, as just one example, especially located in the same cities, I would hope that they would do everything possible and feasible to make that contribution. I know it sounds trite but I believe we are all paid by the same taxpayers to do the same job and there should not be brick wall mentality between well I am a national lab and you are a university. As I said, I think we are all in this together.

Thank you, gentlemen. Thank you, Madam Chair.

Ms. LLOYD. Thank you very much, Mr. Schiff. We thank you for your testimony and we will be submitting additional questions in writing for your answer which will also be made a part of the record. Thank you very much, gentlemen, for being a witness today and for your excellent testimony.

Our next panel will focus on precollege education. Our first witness on this panel is Ms. Vivian Brown, who is a science teacher at Model High School in Rome, Georgia. She is a participant in DOE's program for teachers. Then we are going to hear from Robert Rogers, currently with the Hamilton County Department of Education, a former math and science teacher; followed by Geraldine Farmer, a science consultant with the State of Tennessee Department of Education.

Ms. Brown, we are very interested in your experience as a participant in this program and if you will begin and then we will hear from Mr. Rogers and Ms. Farmer. Welcome, and again I will have to ask you to limit your oral testimony to about ten minutes so we can have time to get into some questions. But your entire statements will be made a part of this hearing.

PANEL 4

STATEMENTS OF VIVIAN P. BROWN, SCIENCE TEACHER, MODEL HIGH SCHOOL, ROME, GA; ROBERT ROGERS, HAMILTON COUNTY DEPARTMENT OF EDUCATION AND GERALDINE FARMER, SCIENCE CONSULTANT WITH STATE OF TENNESSEE DEPARTMENT OF EDUCATION

Ms. BROWN. Thank you. I have participated in several of the programs that have been mentioned here today.

Ms. LLOYD. I think you need to put the microphone a little closer to you.

Ms. BROWN. And have found several of them extremely helpful. I participated in 1987 in the Science Teacher Research Involvement for Vital Education, the STRIVE program at Oak Ridge. And have found several different ways to make that really useful in my classroom as well as sharing it with other teachers in several different programs. There have been a couple of ways that I would like to see that program changed slightly, but only slightly. One of those is to make the announcements of it a little bit broader. In presenting it to the Georgia Leadership Conference, the science teachers there, I found that many of the schools had never heard of the program at all, and even though it is aimed primarily at Tennessee teachers, it is open to other states as well and I believe it can be shared very effectively in other school systems too.

Even when I wrote and asked for their application forms, it still says "Tennessee teacher", and so I felt very strongly that maybe I was not even supposed to apply.

Ms. LLOYD. Well we still feel we own part of Georgia, so that is all right. [Laughter.]

Mr. SCHIFF. They say the same thing about you.

Ms. BROWN. Several of the other programs that have been mentioned here today, I have not had any distribution of materials or information on, and feel very strongly that perhaps that is one of the big weaknesses, that the programs really are not—the announcements are not getting out to all of the teachers. And so that is another one of the big things that I would like to see us change.

There are several different ways that I feel like the national labs could be used more effectively for encouraging our best students to pursue science career research.

One of them is to host a science teacher research conference at each or the national labs, and perhaps invite even more distant teachers than just the individual State or right around the community where they are working, because it certainly gives a new look at how research is going on. A combination perhaps of tour demonstrations or lectures or hands-on experiences and informal sharing might encourage them then to bring back to the labs their very best high school students, or even junior high school students, and perhaps have a similar sort of thing for the student groups as well, where the students perhaps would be allowed a few really hands-on experiences during that interval of time.

One of the things that I have done in the past was to be an Oak Ridge traveling science teacher for the State of Georgia. That has been a good many years ago, but I found it to be a very effective way of sharing. We carried a good bit of information as well as a lot of equipment that was not available in the local schools and we would stay in the school for a week at a time and give lecture demonstrations to the individual classes and to the whole student body. I still real strongly remember how interested and involved the students became with things that they would not have had an opportunity to have seen. These were sharing the things going on in the national labs at that time.

Georgia has the Science Teacher Leadership Conference that attracts a very large number of our very best teachers statewide, from elementary all the way through college teaching. And I believe that if the national labs could send a great many of their very best speakers and share some of the information there, that that too might be a way of getting additional information to the science teachers, because I find that Science Leadership Conference to be a real spark that just enlightens my teaching, it just adds a great deal of enthusiasm and a way of sharing a great deal more than we can get at other times. Somehow when you are in your own little school, you sort of lose track of what is going on in research, even though you have been involved for awhile at one point, you sort of get lost. And so you do need some revitalization and to know a little bit better about what is going on. So I think that would be an excellent opportunity to share with some of the science teachers.

We also, while I was at Oak Ridge, saw a very large number of very excellent presentations that many of the researchers did. Perhaps videotapes might be able to be shared where the professors are too far away, in schools that just the distance makes it almost impossible to invite the person there. That could also include some of the research materials in the video, so that they would be able to share that way.

I suppose if I were asking for one thing most, it would be equipment and money for repairs of the present equipment though, and even some of the equipment that perhaps is discarded in government offices, researchers, or anything else of that sort. For instance, I have bought discarded equipment and used in my high school laboratory a number of different times. It seems to me that perhaps when it becomes outmoded in the national laboratories, that perhaps it could be passed along to the high schools and maybe even middle school equipment too.

I suppose if I could have one other specific request, it would of course involve money, as it usually does, but science aids in our high schools and middle schools or some other kind of coordination of equipment and materials so that the sharing of expertise and equipment and materials could also be accomplished.

In the school where I teach presently, we are just so badly overcrowded and have so little space and equipment that you just see the tremendous need. It is no wonder that we are not doing any better job than we are doing, I think.

There are some other kinds of things that I would perhaps suggest. One might be a traveling actual laboratory that was designed and brought into a particular school system and bring some students in, so that we actually had some equipment and materials that perhaps are just entirely too expensive, but many of our students really need to get turned on at very early ages I think. I think we are losing them even before we get to the high school too often. I have grandchildren now and I find them just enthusiastic and as a former fourth grade teacher, I found fourth graders just eager and ready, but somehow by the time they get to high school, much of that enthusiasm has already been turned off. And so I think that to focus down at lower levels even is extremely important, and I think that too often we wait and hope that they will get there, to the college level. But this is a part of what is wrong with our program, that we need to maintain and encourage that enthusiasm early.

Another consideration might be given to extra training and expertise during the training of actual teacher training. One of the things that we did as a traveling science teacher was to work with the teachers in training during the summer and also during in-service days in the schools. So I think to promote—you have the Tennessee traveling scientists available, but to encourage some of those perhaps to be available to other States or to other—in other areas, might be helpful too. One of the things that I find too is that when we have the young people with the natural curiosity and interest and all the rest, again to know exactly how to encourage them to go on and to find special uses for what I think is ways that maybe the national labs can be even more useful.

[The prepared statement of Ms. Brown follows:]

TESTIMONY OF VIVIAN PRENTICE BROWN
A Science Teacher at Model High School
Rome, Georgia

I have taught 4th grade, 7th grade, high school, and college science classes for more than 30 years. I started Georgia Junior Academy of Science Clubs in several Floyd County Schools, served as an area coordinator for science fairs, and served as State Director for Georgia Junior Academy of Science. I also served as an Oak Ridge Traveling Science Teacher for the State of Georgia.

During the summer of 1987 I participated in the Science Teacher Research Involvement for Vital Education (STRIVE) program at the Oak Ridge National Laboratory. I found the STRIVE program to be excellent and one that enriched my science teaching.

I have used these experiences to develop a field ecology laboratory experience which I use in my biology and ecology classes. I also find that class discussions in physical science give many opportunities to share information and experiences from Oak Ridge.

I have also shared these experiences with local science teachers and with district science teachers state wide this winter at the Georgia Science Leadership Conference.

I found the STRIVE program to be so helpful that I have applied again and have been accepted at the Savannah River project for this summer.

I would like to see the STRIVE program made available for more teachers. There are two minor changes in the program I believe would be helpful. The application form for the STRIVE program needs to be changed so that it says it is open to teachers other than in the state of Tennessee. One other improvement I would suggest is to make available-- at least on a loan basis--the slides, videos, or other visual aids used by the science teachers to share their experiences with the other STRIVE teachers. This would make the sharing of these experiences much more interesting for students.

A few other suggestions for ways the National Labs could be used more effectively to interest and encourage more of our best students to pursue scientific research as a career follow:

Host a Science Teacher Research conference at each of the National Laboratories. Invite one or a few elementary, middle school, and high school teachers from each school district to come to the National Lab for a few days or a week. There, a combination of tour demonstrations, lectures, hands-on experiences, and informal sharing time might encourage them to later bring their most interested students back and to share with other teachers back home the research going on.

This might be followed by a conference for students and teachers. This could involve tour-demonstrations and as much as possible hands-on experiences in small groups in several labs there. Ideally students would be allowed to choose the areas that interested them most from a description of work in progress given by the researchers.

Traveling science teachers or traveling laboratories might also be used. When I did this we went by invitation to a school and stayed usually for a week. We gave lecture demonstrations to science classes and usually also an assembly program to the whole school. I still remember the excitement of many students as they crowded around to see more and ask questions after the demonstrations.

I don't know how many other states have a Science Teacher Leadership Conference such as Georgia has, but that would also be an excellent place to share the research going on. Atlanta, Georgia, will be hosting the National Science Teachers Conference next year. This would also be an ideal audience for some of the scientists to share their research with. I heard many excellent presentations while I was at Oak Ridge. The best of these could also be video-taped to be used in schools too far away to make visits feasible.

Equipment grants to schools or grants to systems for equipment to be shared by all schools would really be helpful. A science department aide for each school would also be a tremendous way to help.

Frustrations of science teaching are primarily lack of money for adequate equipment and repairs. Facilities and space are also a serious limiting factor. Time to set up and put up equipment and the tremendous increase in paper work also add to the problem.

To help you understand, let me describe my own situation. Our school is badly overcrowded with very inadequate laboratory facilities. Almost half of my lab stations do not have running water or gas outlets.

The 8th grade science teacher has no laboratory space at all available to her and two other high school science teachers must float from room to room. In addition to the hardship this places on the floating teacher, it means that labs cannot be set up or put away during planning time.

We also need badly a central storage area because the equipment that I must use, for example, is stored in four different classrooms.

When I asked my students and fellow teachers the best place to target additional motivational help to develop science interest in students, most said middle grades but that it would have to be maintained at the high school level and I concur.

Elementary grade students, however, have a natural interest that needs to be aroused too, I think. Therefore I believe it would be a mistake to target just one level of students.

Another important consideration could be science teachers in training. When I was an Oak Ridge Traveling Science Teacher, we spent the summer giving lecture-demonstrations to science education classes. In-service days during the school year would be another way traveling scientists, science teachers, or science labs could be used.

Finally, the museum at Oak Ridge is nice but if it could have more recreational facilities associated with it-- similar to the space center at Huntsville, Alabama--I believe it would draw a much larger audience. We take the science club to Huntsville every year or so but almost never to Oak Ridge.

Ms. LLOYD. Thank you very much. That is excellent testimony. Mr. Rogers, I understand you have some very definitive ideas on the subject from your earlier days as a junior high school teacher.

STATEMENT OF ROBERT ROGERS

Mr. ROGERS. I find it amazing how closely our ideas and sentiments parallel each other, I think——

Ms. LLOYD. We are looking forward to your testimony, please begin.

Mr. ROGERS. I am going to begin my remarks with a bit of an anecdote. I teach a physics class at seven o'clock every morning at one of our local high schools. I had occasion a couple of weeks ago to ask the group of students that I am teaching this year if they had ever seen some of the simple science experiments, for instance running a comb through a person's hair and picking up pieces of paper or making an electromagnet with a flashlight battery, a nail and some insulated wire. And out of the 23 students that were present that morning, two of those students had seen such simple experiments of that nature. I believe that that is a very good illustration of some of the problems that this Subcommittee is addressing.

My own view of the situation as it stands right now is that we are losing our science students in the elementary schools. Any emphasis that is placed on science education, in my opinion, should be directed at elementary schools and the target population I think we are pretty much in agreement should be the teachers. There are two or three things that can be impacted there, and I have to be very careful here. I have had to warn myself a number of times that the Department of Energy cannot fix all of these things, but the Department of Energy I think has some existing programs that are excellent and should be continued and expanded as much as absolutely possible. But I think that anything that we can do to enhance the level of preparedness of our elementary school teachers is what we should be about. Anything that we can do to help them excite our young people to maintain this level of interest and enthusiasm about learning about our natural environment, those are the things that we need to be doing.

I also believe very strongly that the solution to these problems and the pathways that we set for ourselves are going to be dependent upon science education becoming a national priority. I personally believe that that national priority would be established in this one large burst I think that has been referred to a number of times today. It worked a couple of times in the past, the late 1950's, early 1960s, it produced some rather interesting results. I do not know that I would advocate another space race or anything of that nature, but I believe that the Department of Energy is an agency that could impact very heavily the national awareness of the importance of science education. But I do not want to leave the impression that the Department of Energy either is the only agency that has responsibility where this is concerned.

I am also very concerned about the national agenda. We have, as I see it, a national agenda at present that is concerned primarily with basic skills. I see that as part of our problem. Basic skills have brought about an increased emphasis on mathematics skills and language skills to the detriment of such things as science education, social studies education is another thing you hear mentioned prominently of late.

I do not want to leave the impression here that I am an advocate of another situation wherein public schools and public school systems and public school teachers are compared via the standardized test route. I think if that were attempted where science education is concerned, we would end up with a group of students who were very well versed in the rote memory types of things. We would be very good at teaching them vocabulary and fail to address the extremely important concept that science is a process, science is something that kids do. We cannot teach science in a situation where kids are sitting in the traditional elementary school, middle school or high school classroom with individual student desks. You cannot teach science in that environment. What we have to have is laboratories, what we have to have is equipment, something besides the equipment that we managed to purchase in the 1950's with the money that was generated as a result of Sputnik. What little of that stuff that is left is in dire need of repair.

The idea that was mentioned just a moment ago about the equipment that is used in our national laboratories that does become obsolescent but far earlier than the equipment that we use in the public schools, I think that a practical use of some of that equipment, if it were still usable, would be to hand it down to us and let us see what we can do with it, let us expose our students to it and I can just about guarantee you that they would come out of our public high schools a lot better prepared than they are now to enter into a laboratory situation and be productive.

It was mentioned earlier in the day a couple of things that kind of tie in together. One of these things I find that I have been the victim of. One of the students who is in my early morning science class was a recipient of one of these summer study fellowships this year at the Argonne National Laboratory. This was the first time in my 21 year career as a science teacher that I had heard of those programs, and I think the point was very well made this morning that sometimes these programs are very well known in their immediate impact areas and not so much in some other places, and I think that an informational campaign about opportunities of this nature might be of some value.

Along that same line, an information network that would serve to disseminate timely information such as the information that is very popular right now relative to the cold fusion research. My remark has been that most of our information has come through the news media. And I know in several circumstances it would have been extremely valuable to have had some information beyond that that has been made available to us in the press.

Another idea that I heard mentioned this morning that I think would be very valuable, that would relate to some of the other feelings that I have about the current problem in the science education field and some of the ways that the Department of Energy and the national laboratories could impact this, is a situation wherein science teachers could be exposed to current research, current research methods, developing machines and that sort of thing, a program wherein science teachers would be able to work in research facilities in the summer time. That would solve, I think, two problems. It would keep teachers abreast of developments in the sciences and it would also serve to have some impact upon one of the other major problems that you hear teachers in all fields talk about and that is the money problem, their own personal finances. And I do not think there would be too much disagreement with the simple statement that the education profession is an underpaid profession. And that is one of the problems. The things that teachers have to do to make ends meet does take away from the amount of time that they are able to spend—not that they are willing to spend, ladies and gentlemen, but they are able to spend in keeping abreast of developments and retraining themselves. They have their families to think about too. I will stop while I am ahead. Thank you very much.

[The prepared statement of Mr. Rogers follows:]

THE ROLE OF NATIONAL LABORATORIES IN SCIENCE EDUCATION: A TEACHER'S PERSPECTIVE.

BOB ROGERS

THE PROBLEMS:

1. Science education is not a real priority in public schools. The evidence supporting this statement appears in almost all public school buildings. Elementary schools have no laboratory facilities nor do they have equipment and materials necessary to teach science. Laboratory facilities that do exist at the secondary level are, at best, inadequate. Laboratory space is insufficient. Laboratories often double as classroom and/or lecture halls. The laboratory equipment, materials, and consumable supplies were purchased during the last national burst of interest in science education: the late 1950's and early 1960's.

2. Science is not perceived as being a "basic skill." The national, state and local fervor to improve the basic skill levels of American students has produced an increased emphasis on reading and mathematics. The curricular approaches and available materials do not appear to reflect the fact that students can read about science and that quantification of phenomena is the most practical application of mathematics skills. The result has been that, "with all the emphasis on basic skills, there is no time to teach science."

3. The policy of using standardized test data to compare schools and school systems has served to de-emphasize science education. Schools and school systems have placed their energy and resources in those areas that are most commonly measured and compared via standardized test scores: math skills and language skills.

4. Teachers teach best those things with which they are most familiar. Education training programs do not adequately address science. Therefore, elementary teachers avoid science. This has the effect of causing students to not become interested in science. We do not necessarily "turn students off" but neither do we "turn them on."

5. Advanced science courses are directed toward a very narrow range of student abilities. Very little has been done to increase the number of students that are exposed to upper level science course.

6. The diversification of science course becomes evident only at the high school level. Exploratory experiences are thereby quite limited during those years wherein students are most curious and interested.

POSSIBLE ASSISTANCE THROUGH THE NATIONAL LABORATORIES:

1. Begin a program that has as its goal the establishment of science education as a national priority. The Department of Energy through the National Laboratories is the logical agency to provide the information that would demonstrate the need for such a goal.

2. The fact that the National Laboratories can have a significant impact on science education is wonderfully demonstrated in the Oak Ridge Area. Oak Ridge students consistently out perform their Tennessee peers in science areas. Argonne National Laboratories has recently awarded Ooltewah High School Senior James Paris a scholarship to study there during the summer of 1989. Expansion of programs such as these can only serve to positively affect more students.

3. Continue and expand teacher training and retraining programs. Any effort to raise the knowledge and awareness levels of those primarily responsible for providing instruction is of significant value.

4. Establish a program whereby surplus usable equipment can be placed in public schools rather than being sold at auction. Any type of equipment from the simplest to the most complex would be useful in helping to motivate students into the study of science. Given appropriate laboratory opportunity with modern equipment, students would emerge from public school science programs significantly more prepared for educational experiences at high levels or for specific vocational training and experience. The Department of Energy should also encourage the private sector to participate in similar programs.

5. Direct more training programs to elementary school teachers. If we fail to capture the imagination and interest of these younger students we lose on two fronts: first, the number of students exposed to science education is dramatically reduced, and second, the interest level of those students who are exposed to science education is significantly reduced. Generally, the more knowledgeable teacher is a better teacher. Teachers need help in motivating students. Increased knowledge levels among teachers make them more comfortable and, therefore, better able to motivate.

6. Promote the concept that science is something that kids do. Science is a process, not just a body of knowledge. Hands-on experiences and exploratory experiences are essential at all levels of science education. "Bells and whistles," pretty colors, loud noises and bad smells are trademarks of science. These things get students' attention.

7. Initiate a program that assures the timely dissemination of factual information relative to current developments in the area of research. During recent weeks, teachers have depended upon newspaper accounts of the research on "cold fusion" as a resource to answer questions from students and parents. We need better information.

BR:amd

Ms. **Lloyd**. That was excellent testimony. I enjoyed reading your prepared testimony as well, Mr. Rogers. We will finish with you, Geraldine. Share your microphone.

STATEMENT OF DR. GERALDINE T. FARMER

Dr. **Farmer**. If you see that I am shaking it is because, number one I am nervous and number two I am cold. It is freezing in here today.

Ms. **Lloyd**. I may be able to do something about the latter, but the first one, all I can say is welcome and we certainly do not want to frighten you because we know that you are an extremely well-informed lady and we just want to hear what you have to share with us.

Dr. **Farmer**. If you will give me that doctorate you gave to the fellow from TVA, that would help.

Mr. **Schiff**. A little stereotyping perhaps?

Dr. **Farmer**. Well I wonder if it was because I was female or a minority that it was left off.

Mr. **Schiff**. My bet is it is because you are female. [Laughter.]

Dr. **Farmer**. I work with the State Department of Education. I am a former classroom teacher and it was rather difficult to decide how to present testimony, but I am going to attempt to do that without commenting on what has been said before.

At the State Department of Education about 1985, it was decided that there should be some continuity to our educational program and out of that deliberation came what we call the basic skills program. That basic skills program included the language arts and it included mathematics, but it did not include science. Years later however, it was decided that maybe it would be a good idea if we knew what would be in each course, not just basic skills. So at that time science was included to the extent that we developed a curriculum framework at the state level.

This framework defines what will be taught in the science classes, K through 12. This framework is presented to local education agencies and they have an option of developing curriculum guides to highlight, beef up, explain implementation strategies as to how they can convey this material to students. But the state also develops the guide. So in some instances, most instances in fact, the state guide is used.

Because this is a rather long and difficult process, this is repeated every six years. And we all know that in science, six years is a long time to take a look at what has gone before. This curriculum development cycle also includes our textbook cycle. In this six-year process, we have a needs assessment. This includes State and local educators. This could also include Department of Energy staff, I don't think it has in the past. But the needs assessment is to say what is it that we want to happen in science education in our K–12 program. And from this needs assessment the framework is developed.

After the framework is developed, it is presented to all of the publishers of educational materials to say this is what we would like to happen in our schools. They have an opportunity then to correlate educational materials to our framework and in the case of textbooks, submit them for bid. We are a State where there is a State adoption list. And in evaluating these textbooks, one of the things we look at is the extent to which they complement the framework.

After this, we have curriculum guides developed. It is implemented, there are workshops to enhance implementation by classroom teachers, and then we evaluate. As I said, we do this every six years. The first time we did this in science was 1983-1984 school year. Six means that 1989-1990 we are in the process of starting again. So this hearing is very timely and if there are suggestions and ideas that are going to come from it that we could implement into this cycle, this is very appropriate timing.

As we started with the sciences, we discovered—and I was rather new in the State Department at the time, but we discovered that educational equality project of the College Board had been drafted and that our legislators had adopted that program. It is called "Academic Preparation for College: What students need to know and be able to do." That caused us to go back and look at our framework and our guides again to see if we in fact were doing those things that project equality asked for. And it is actually attempting to do the same thing we are saying here today, how can we get our students involved, how can we get them into all of our academic competencies, how can we prepare them to be productive citizens.

The green book, as we call it in Tennessee, talks about teaching six basic competencies; reading, writing, speaking and listening, mathematics, reasoning and studying in all of the academic areas including the sciences. So this has caused a mass effort at staff development because biology teachers were not that accustomed to teaching reading or to teaching math, just as an example. So we have tried to pull together ways in which these teaching strategies can be incorporated into all of our sciences.

In doing this, we have had the need to call on colleges for help. So we have now established the Tennessee statewide school/college collaborative for educational excellence, if you can say all that without breathing. Through this collaborative, we have been able to pull together high school teachers, college professors from each of the disciplines as well as from the schools of education. We meet regularly to talk about curriculum. We are trying to identify those places where a high school student will leave high school and can be successful in college and we have found out that we were worlds apart, but we are continuing to meet together to work together, so that we can agree on what is the mission of the high school, and at what level should we have been prepared to be successful in the college.

Part of this EQ collaborative though also talks about the world of work because we realize that all of our students are not college bound. And what we have found is that the basic competencies that we need for college success are also needed for the world of work. This would be another place where the Department of Energy might wish to join with our K-12 program, when we have these collaborative meetings. We would welcome your input.

In this process we have looked at our science courses, we have restructured some of them, we have added new ones. It was mentioned earlier today that principles of technology was one of the programs offered through our vocational program. Also we have a mathematics of technology. So we are looking at ways in which high school students can meet graduation requirements and also get the technical skills they need for the work world. We also add new courses as the need arises.

There is another option, however, where local schools may choose to add a course if there is a need that is not identified at the state level but is identified at the local level, then that local school system can write the framework and submit the course to the State and provide their own local courses.

As we look at our curriculum documents, we are also looking at Project 2061 by the American Association for the Advancement of Sciences or Science for All Americans. We have read the document and feel that it will be one of those things that will be considered as we re-evaluate the curriculum framework for the next six years.

You may be familiar with the mathematics standards that have been recently published by the Tennessee Council of Teachers of Mathematics. That is included in the packet. This is the direction we had already started because of the green book project, and we find that it is very consistent with both documents, both Science for All Americans and the mathematics standards. They are all saying let us do a better job and not try to cover the waterfront. In the past perhaps we have been too broad in our coverage of topics rather than being narrow and developing those critical thinking processes as we were teaching our courses.

We, as I said, have principles of technology, applied mathematics—these are two of the newer things that we have done. We have also instituted a science course through the vocational agriculture department so that students may have four years of agriculture and still meet their requirements in science.

I pulled our Stanford Achievement Test scores from 1985 through 1988 and as we look at science we will notice that we have increased significantly our scoring. We test at the second, fifth and seventh grade, and each year there is a little bit of an increase. I think part of that has been due to the emphasis and insights in recent years. Part of that has been due to the programs through the universities. Through the Center of Excellence in Math and Science at the University of Tennessee at Martin, we have had extensive training in our elementary program. Even though the funding is in jeopardy, we are hoping to keep that program and hope that they continue to train teachers in the sciences.

There is a summary also in computer education in Tennessee. We have a mandatory program at the seventh and eighth grade which introduces students to computers. They all must take that, but there is an optional K–6 computer program where students can become computer literate. And in our high schools we are pushing the interfacing of our labs with computers, especially in our physical sciences.

We also have pilot high schools that are trying to put the whole school system on computers. We are a little behind the businesses where you are already technologically oriented, but we are moving in that direction as fast as funds will allow us. We have certification requirements for computer courses as well as we have revamped our entire teacher education policy. I did not included the license and standards, I just included the cover, but those are public documents if you would like to see them. So beginning in a few years, we will have new policies for how teachers receive a license to teach in Tennessee.

I think my ten minutes are about up, so let me summarize as to what I see some of the ways in which the national laboratories may be of further assistance to us.

Summer enrichment programs have already been mentioned. One of the problems, as I see it, and I do happen to administer the seven programs for the summer, and I can assure you that all of the high schools were mailed copies of your announcements, but when you look at the requirements they want the best and they want the brightest and I feel that this perpetuates the myth that only the very best students can be successful in science. I have tried desperately to get minority participation in these programs, but if I follow the guidelines there, then it is very difficult to get minorities who will meet the expectations as described in the brochure.

I think programs that meet the needs of the middle range students, the average student, would be helpful and just as beneficial to the student and the national laboratory. The same thing I think is true for our teachers. I have reviewed some of the applications of teachers that were coming into the labs and it is usually the science majors that are selected, not the science teachers who also have 150 students a year, but the science teacher that is weak. It is usually the best programs. There is a need for that, but there is also a need for programs that will strengthen the base on which we operate.

You have developed curriculum materials over the years and they have been good. I would love to see those continue. I would love to see some staff development programs perhaps by satellite that could be sent out into local schools. I think the technology is there with most of the schools such that if we could develop clusters of physics teachers that could benefit from such programs. It is difficult to have a staff development in the content when there are only two physics teachers in the whole school system. We have 140 school systems and some of them are very small, with one high school. So if in some way we could form some strong local alliances, professional associations where programs could be sent in for staff development, I think that would help us a great deal.

I have another list of needs that you may or may not be able to help with, but I would like to get them in the record. We have a desperate need for elementary science facilities throughout our state. Not that you must have a formal lab for elementary science, but we do need things and we need storage areas. And when you have wall-to-wall students, it is very difficult to set up something that has to stay for a couple of hours.

We need some examination of the workplace and the work load at the high school level. To ask a teacher to have three different preparations, maybe chemistry, biology, science is a very hard task and we need support for teachers who have this number of preparations. I would like to see tuition free undergraduate courses made available for teachers. Some teachers have weak backgrounds. They are not selected for these programs but they would go back and take an undergraduate science or math course if they did not have to pay tuition, and that should not be a big cost to anyone if they could fill in the spaces during the summer when the classes are already there. But that is not available to them. I understand it is available to senior citizens.

I think we need to include science as a basic skill in the elementary grades. It needs to be included as one of the things that you do not wait until Friday, if you have time. It needs to be included along with the other basic skills.

We need staff development time. If we have teachers in the schools that need development or need training, we need time to do it. They should not have to sacrifice to go back to get that training.

We have several things that have shown a turnaround I think in our elementary program. We have the Governor's School as has been mentioned. It has been operating several years, it is always full and running over. But again, it is for the geniuses, the better students. And those students who could benefit just as much get left out. We have our Junior Science and Humanities Symposium and we have students that do their research, write up their papers and they are willing to present it. The Junior Academy of Science—but we also have some programs that are not as discipline oriented as those and they are really on the increase. One is the Science Olympiad where teams of average students get together and show that they can build things and get together and earn trophies, earn ribbons, earn medals for something that they did themselves. We also have Invent America, you perhaps are familiar with that one. It is growing in our State. The Invention Convention and our science fairs. All of these programs are growing, we are getting some parent involvement with them, and I think that as we continue to grow and as we continue to get parents involved, we will strengthen our programs more than we have.

In summary, we need parent involvement beyond the lower grades, this is one of the keys. When kids become disinterested in school, it is about the time parents stop coming to school. We need role models in our research laboratories visible to the public, we also need them in our classrooms. The number of minorities in Tennessee classrooms has dwindled considerably. We need the enrichment programs, but we need to re-evaluate the selection or extend them to include students that are not at the very top of the class, and then we need the staff development activities which is time to teach science in the elementary school, support from either the local or the State or the colleges, from some level so that when these teachers run into problems there is a support system, content area in-services, and work together to strengthen our professional science organizations.

[The prepared statement of Dr. Farmer follows:]

EDUCATION IN TENNESSEE--SCIENCE - MATHEMATICS - TECHNOLOGY

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EDUCATION IN TENNESSEE-- SCIENCE- MATHEMATICS- TECHNOLOGY

I. CURRICULUM DEVELOPMENT

Frameworks and Guides
Curriculum Development Cycle
Textbooks

Recent changes in course offerings
Vocational Education
Special Course Option

II. STATE TEST RESULTS

III. COMPUTER AND TECHNOLOGY EDUCATION

Computer Skills Next
High School Electives
Optional K-6 Computer program
Employment Standards

Technology Advisory Committee

IV. TEACHER EDUCATION PROGRAM

Teacher Education Policy
Licensure Standards

V. COLLEGE AND UNIVERSITY ADMISSION REQUIREMENTS

Board of Regents
Board of Trustees

Honors Diploma

VI. NATIONAL LABORATORIES

Student Enrichment
Staff Development
Community Outreach

TENNESSEE CURRICULUM CYCLE

State Board of Education rules (Section 0520-1-3 .02) establish a six-year cycle for the development and implementation of curriculum frameworks and guides in all subject areas. Subject areas will be at different points in the cycle at a given time.

There are three areas of activity in the curriculum cycle:

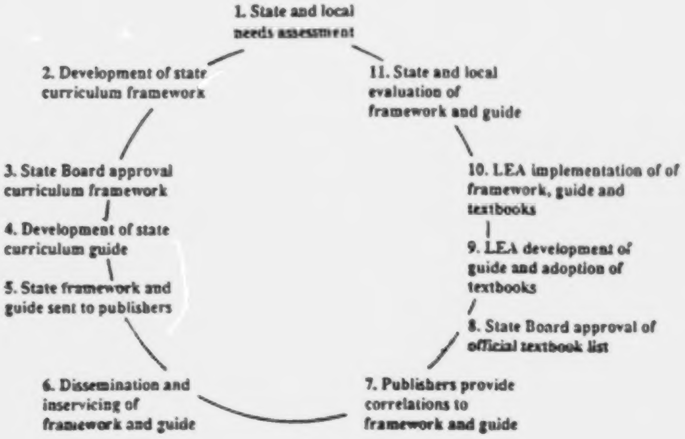
1. **State Department of Education** -- Working with local educators, the State Department of Education begins the curriculum cycle by evaluating the needs of students in a particular subject area. The Department then develops curriculum frameworks outlining the objectives of instruction in a subject area. When the framework for a subject area has been approved by the State Board of Education, the Department develops a more detailed curriculum guide.

The Department distributes the guides and frameworks to local school systems at least one year before new textbooks are introduced, and also provides inservice training in using the frameworks and guides to local educators.

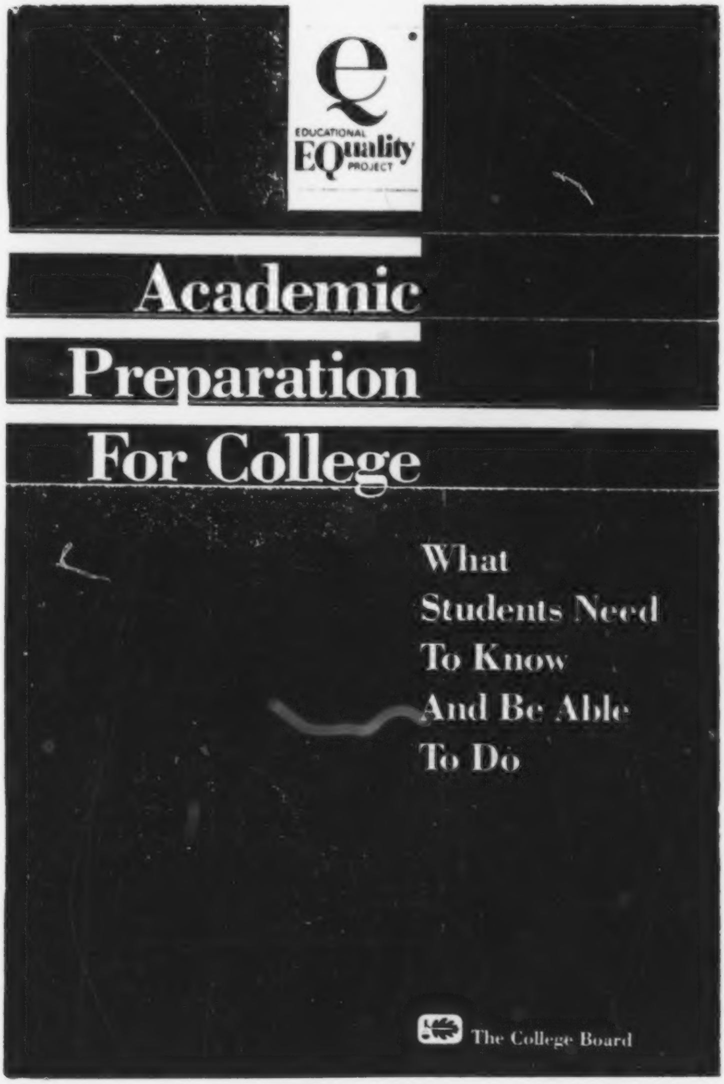
2. **Textbook Commission/State Board of Education** -- The Textbook Commission then submits the frameworks approved by the State Board of Education to textbook publishers before July of the textbook approval year. The publishers in turn correlate their textbooks with the frameworks, and return those correlations to the Textbook Commission before October of the textbook approval year. The State Board approves the official list of textbooks in November of that year.

3. **Local Education Agencies** -- LEAs may choose to develop their own curriculum guides. If so, they must have them completed by the end of the school year after the State Board has adopted the official list of textbooks. LEAs using the state curriculum framework and guides are trained in the year before new textbooks are introduced. They must implement the framework and guides in the first school year after newly adopted textbooks are used.

The curriculum cycle:


1. State and local needs assessment
2. Development of state curriculum framework
3. State Board approval curriculum framework
4. Development of state curriculum guide
5. State framework and guide sent to publishers
6. Dissemination and inservicing of framework and guide
7. Publishers provide correlations to framework and guide
8. State Board approval of official textbook list
9. LEA development of guide and adoption of textbooks
10. LEA implementation of of framework, guide and textbooks
11. State and local evaluation of framework and guide

SUBJECT	FRAMEWORK DEVELOPED	TEXTBOOKS ADOPTED & GUIDE DEVELOPED	TEXTBOOKS IMPLEMENTED	FRAMEWORK & GUIDE IMPLEMENTED
Social Studies	1982-83	1983-84	1984-85	1985-86
Health, Physical and Safety Ed.; Science and Environmental Ed.; Agriculture; Health Occupations and Home Economics Ed.	1983-84	1984-85	1985-86	1986-87
Language Arts, Foreign Languages	1984-85	1985-86	1986-87	1987-88
Mathematics	1985-86	1986-87	1987-88	1988-89
Fine Arts; Driver Ed.; Business Ed.; Industrial Arts; Vocational-Technical Ed.; Trades and Industrial Arts	1986-87	1987-88	1988-89	1989-90
Reading	1987-88	1988-89	1989-90	1990-91



EDUCATIONAL EQuality PROJECT

Academic Preparation For College

What
Students Need
To Know
And Be Able
To Do

The College Board

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EDUCATIONAL EQUALITY PROJECT

The Educational EQuality Project was launched in 1980 as a ten-year effort to strengthen the academic quality of secondary education and to ensure equal access to postsecondary education for all students. The capital *E* and *Q* of the project's name symbolize this dual emphasis on *equality* and *quality*. As a major high school reform effort, the EQuality project seeks excellent education for *all* students.

Defining Goals

Nationwide discussions about what college-bound students need to know and be able to do marked the early stages of the EQuality project. In the course of three years, more than 1,400 high school and college teachers worked to define explicitly the essential knowledge and skills students need to be fully prepared for college-level study. These teachers identified learning outcomes in six Basic Academic Competencies and six Basic Academic Subjects, as well as an emerging need for computer competency. Their work resulted in the now widely used publication *Academic Preparation for College*. More than 300,000 copies of this "Green Book" are in circulation and many states and school districts are using it to convey expectations and to examine their curricula.

Achieving the Goals

Academic Preparation for College outlines the desired results of high school education--the learning all students need in order to have a fair chance at succeeding in college. The EQuality project and the teachers who formulated the learning outcomes and competencies hold that there is no single way to teach the competencies and subjects; curriculum and instruction are matters of local expertise and responsibility. Nevertheless, many educators have asked for a fuller picture of the goals and for suggestions about how the goals might be translated into classroom practice. With the help of the College Board's Academic Advisory Committees, the EQuality project is publishing six books, one in each Basic Academic Subject, suggesting some ways the outcomes might be achieved: *Academic Preparation in English*, *Academic Preparation in the Arts*, *Academic Preparation in Mathematics*, *Academic Preparation in Science*, *Academic Preparation in Social Studies*, and *Academic Preparation in Foreign Language*. On the basis of these books the project is encouraging further national discussion about what should be happening in our high school classrooms and is also launching in-service workshops for high school teachers.

Motivating Students

Meetings with business leaders during the early stages of the EQuality project established that students who enter the work force directly from high school

THE COLLEGE BOARD

need many of the same academic competencies as do students going on to college. Since those competencies are learned through study of the academic subjects the EQuality project is working to encourage *all* students early in their high school careers to set high standards for themselves, to choose and stick with an academic course of study, and to turn to their teachers and counselors for support when studies seem difficult or discouraging.

Recognizing Special Needs

Concern with improving the educational attainments of all students increasingly involves concern for students from groups of historically disadvantaged Americans. Achieving equal results requires that students be dealt with—not identically—but in the ways that are most suited to their particular situations. The EQuality project seeks to give--and call--special attention to the situations of students most at risk, students who often do not get access to the academic preparation and support they need.

National colloquia are one way the EQuality project provides this attention. One such colloquium focused on the obstacles Native Americans face in achieving access to higher education. Another colloquium brought school and college educators together to examine the quality of education that black students receive and how they may be affected by current school reform policies and proposals. The background paper for that colloquium--*Equality and Excellence: The Educational Status of Black Americans*--has been widely distributed and publicized.

The EQuality project also works closely with other national organizations specifically concerned with the needs of minority students. For example, one staff member participated on the recently convened National Commission on Secondary Schooling for Hispanics.

Teachers Helping Teachers

A recent publication of the EQuality project, *Teaching in America: The Common Ground*, presents accounts of how New Haven teachers in secondary school and Yale University faculty come together to prepare a broad variety of curriculum units for use in the public schools. The richness of their academic collaboration and co-professionalism reinforces the EQuality project's conviction that teachers working together are key to improving the education of all students.

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Schools and College Working Together

The EQuality project's Models Program for School-College Collaboration encourages, assists, and supports collaborative arrangements between colleges and secondary schools. In establishing a network of these collaborative arrangements in 1983, the project intended to provide a means by which promising practices, materials, and research could be shared. It also intended to study the extent to which these arrangements may serve as "models" to facilitate similar efforts elsewhere. Now numbering 15, the collaboratives vary in organization, composition, and development, but all share in a central commitment to increase the number and diversity of students adequately prepared for higher education.

Assessing Progress

The Educational EQuality Project believes that assessment should be used to support instruction and curriculum not just to sort students. The project is investigating what role assessment can play in helping schools improve the academic preparation of students for college, what kinds of new examinations or assessment services can help expand and diversify the pool of students prepared to enter and succeed in college, and how well current tests measure the skills and knowledge needed by students entering college.

Looking Ahead

Dialogues about improving the education of all students will continue to be intrinsic to the EQuality project. New publications, research, colloquia and workshops are being planned to further the goal of having more students better prepared for college. To stay current with activities of the Educational EQuality Project write or call the appropriate College Board Regional Office. To order publications, see the list on the reverse of this page.

Comprehensive Education Reform Act

Section 99.9 of CERA of 1984 states:

Within five (5) years after passage of this act it is the legislative intent that the instructional program shall be improved to provide measurable improvement in the subjects of Chapter II "The Basic Academic Competencies," Chapter III "Computer Competency: An Emerging Need," and Chapter IV "The Basic Academic Subjects," all as set out in Academic Preparation for College: What Students Need to Know and Be Able to Do, published by the College Board, 888 Seventh Avenue, New York, New York, 10101, 1983.

PROJECT EQUALITY

Basic Academic Competencies

READING

WRITING

SPEAKING AND LISTENING

MATHEMATICS

REASONING

STUDYING

Basic Academic Subjects

ENGLISH

ARTS

MATHEMATICS

SCIENCE

SOCIAL STUDIES

FOREIGN LANGUAGE

GREEN AND RAINBOW BOOKS

The Center of Excellence is now able to provide the Green and Rainbow Books for Project EQuality at the discount available from College Board for large orders. The postage and handling charges are being paid by The University of Tennessee and the State Board of Regents, two of the cosponsors of Project EQuality.

The following materials are available at the price of $3.48 each (a discount of 50%):

Academic Preparation in the Arts
Academic Preparation in English
Academic Preparation in Foreign Language
Academic Preparation in Mathematics
Academic Preparation in Science
Academic Preparation in Social Studies

The following materials are available at the price indicated (a discount of 20%):

Academic Preparation for College
(The Green Book) $0.80 each

Slipcased set of the six titles in the Academic Preparation Series plus a copy of The Green Book $16

These materials may be ordered by sending a purchase order or enclosing a check with the order. There is no postage or handling charge. The order should be mailed to:

The Center of Excellence
Gooch 145
The University of Tennessee at Martin
Martin, TN 38238-5029

Provided by Karen Hanna, Mathematics Consultant
Tennessee Department of Education
Suite 214, Cordell Hull Building
Nashville, TN 37219
(615) 741-7856

The Tennessee State-Wide School-College Collaborative for Educational Excellence

Purpose

All students entering college deserve a reasonable chance of success. While many factors impact success in college, academic preparation received during high school is a prime one. Institutions governed by the Tennessee State Board of Regents and The University of Tennessee enroll approximately 150,000 students, most of whom are products of Tennessee's public secondary schools.

The Tennessee Collaborative effort - drawing on resources from all of Tennessee public education and The College Board - seeks to improve - academic preparation for these Tennesseans.

Academic Preparation for College, representing the combined judgments of hundreds of educators in every part of the country, is a product of The College Board's Educational EQuality Project. It describes what college entrants need to know and be able to do. Tennessee law - the Comprehensive Education Reform Act - endorses this document; it stipulates that secondary school instructional programs shall provide ''measurable improvement'' in the competencies there defined.

The Tennessee Collaborative seeks to build a broad understanding of academic expectations for college entrants. By bringing together lay and professional representatives of collegiate institutions with various K-12 constituencies and with others who determine educational policies and priorities in Tennessee, the Collaborative will focus on the bridge between high school and college and on means for crossing it successfully.

Sponsored by

- **The Tennessee State Board of Regents**
- **The University of Tennessee**
- **The Tennessee Board of Education**
- **The Tennessee Department of Education**
- **Educational EQuality Project**
  The College Board

1985-86 Major Projects

A major state-wide Conference to announce the Collaborative and to orient the 300 participants to the problem of student underpreparation and to Project EQuality objectives.

Action Agenda recommendations prepared by Disciplinary Task Forces in English, mathematics, and the sciences.

Awareness Workshops presented for public school administrators in each of Tennessee's nine developmental districts.

Green Book competencies integrated into the State Department of Education disciplinary frameworks and curriculum guides.

Local Initiatives to bring high school and college faculty together to collaborate on curricular changes which will improve the academic preparation of high school graduates.

1986-87 Major Projects

Action Agenda recommendations prepared by Disciplinary Task Forces in social sciences, the arts, foreign languages, English, mathematics, and the sciences.

Teacher inservice activities designed to work with teachers on projects related to the Collaborative.

Reports of assessment and placement of college freshmen provided to high schools from which they graduated and workshops to help public school personnel interpret and use the assessment data productively.

Awareness Workshops for all high school counselors and preparation of a Counselor's Task Force report completed.

Local Initiatives to bring high school and college faculty together in all academic subjects.

1987-88 Major Projects

Disciplinary Task Forces developed curriculum, frameworks and guides, developed Teacher Education competencies, and recommended critical actions.

Collaborative goals and Project EQuality materials integrated into Teacher Education objectives.

Local Initiatives to bring high school and college faculty together in local communities, including four Academic Alliances of foreign language teachers.

Tennessee Collaborative/Urban League Task Force established to plan parent workshops.

Materials to clarify 1989 university admission requirements published and distributed.

Tennessee Collaborative Academy established with the College Board as a model program that focuses on "Problem Posing" as a teaching strategy for 120 teachers.

1988-89 Proposed Projects

Convene Disciplinary and Counselors Task Forces to consider Action Agenda, propose activities, and identify major issues.

Establish a teacher inservice state-wide network as follow-up to the summer 1988 Tennessee Collaborative Academy.

Encourage and facilitate regional and local Collaborative organizations and networks to bring college and high school teachers together on a regular basis.

Work with Urban League Task Force to identify and plan joint projects.

Develop curricular and informational materials to encourage student planning and preparation for college admission and success.

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COURSE OFFERINGS IN THE SCIENCES

GENERAL SCIENCE I

GENERAL SCIENCE II

EARTH SCIENCE

PHYSICAL SCIENCE

BIOLOGY I

BIOLOGY II

CHEMISTRY I

CHEMISRTRY II

PHYSICS

PHYSIOLOGY

SCIENCE COURSES THROUGH VOCATIONAL EDUCATION

O PRINCIPLES OF TECHNOLOGY

O GENERAL SCIENCE IA

CURRICULUM FRAMEWORKS WILL BE DEVELOPED IN THE AREAS OF

O GEOLOGY (GEOSCIENCE)

O ECOLOGY AND THE CONSERVATION OF NATURAL RESOURCES

OTHER OPTIONS ARE AVAILABLE THROUGH SPECIAL COURSES THAT MAY BE DEVELOPED BY THE LOCAL EDUCATION AGENCY

PROJECT 2061

SCIENCE

AMERICAN
ASSOCIATION FOR THE ADVANCEMENT
OF SCIENCE

STATE OF
TENNESSEE

Rules, Regulations,
and
Minimum Standards
for the
Governance
of
Public Schools
in the
State of Tennessee

1796

BOOK ONE

- Preface
- Administration Rules and Regulations
- Minimum Requirements for the Approval of Public Schools
- Vocational Education Regulations
- Private Schools

**State
Board
of
Education**

**State
Board
for
Vocational
Education**

**Nashville
Tennessee
37219**

RULES, REGULATIONS, AND MINIMUM STANDARDS
Mathematics Courses
Approved April 25, 1986
State Board of Education

Arithmetic II

Applied Mathematics I and II

Pre-algebra

Algebra I

Algebra II

Unified Geometry

Trigonometry(1/2)

Advanced Mathematics Survey(1/2 or 1)

Calculus(1/2 or 1)

Advanced Algebra

Analytical Geometry(1/2 or 1)

Probability and Statistics(1/2 or 1)

COLLEGE AND UNIVERSITY ADMISSION REQUIREMENTS
FALL 1989

The University of Tennessee

SUBJECT AREA	UNITS
English	4
Algebra	2
Geometry, trigonometry, advanced mathematics, or calculus	1
Natural science, including at least one year of biology, chemistry, or physics	2
American History	1
European history, world history, or world geography	1
A single foreign language	2

State Board of Regents

SUBJECT AREA	UNITS
English	4
Visual and/or performing arts	1
Algebra I and II	2
Geometry or other advanced mathematics course with geometry as a major component	1
Natural/physical science, including at least one unit, with lab, of biology, chemistry, or physics	2
Social studies, including history, government, geography, sociology, psychology, economics, or anthropology	1
A single foreign language	2

For additional information, write the Admissions Office of the particular campus

The major emphasis in mathematics is in programs to train teachers in cooperative learning strategies and techniques, mathematical applications, higher order thinking skills, and problem solving. Tennessee is moving toward the standards that were recently established by the National Council of Teachers of Mathematics.

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SUMMARY OF CHANGES IN CONTENT AND EMPHASIS IN K–4 MATHEMATICS

INCREASED ATTENTION

NUMBER
- Number sense
- Place-value concepts
- Meaning of fractions and decimals
- Estimation of quantities

OPERATIONS AND COMPUTATION
- Meaning of operations
- Operation sense
- Mental computation
- Estimation and the reasonableness of answers
- Selection of an appropriate computational method
- Use of calculators for complex computation
- Thinking strategies for basic facts

GEOMETRY AND MEASUREMENT
- Properties of geometric figures
- Geometric relationships
- Spatial sense
- Process of measuring
- Concepts related to units of measurement
- Actual measuring
- Estimation of measurements
- Use of measurement and geometry ideas throughout the curriculum

PROBABILITY AND STATISTICS
- Collection and organization of data
- Exploration of chance

PATTERNS AND RELATIONSHIPS
- Pattern recognition and description
- Use of variables to express relationships

PROBLEM SOLVING
- Word problems with a variety of structures
- Use of everyday problems
- Applications
- Study of patterns and relationships
- Problem-solving strategies

INSTRUCTIONAL PRACTICES
- Use of manipulative materials
- Cooperative work
- Discussion of mathematics
- Questioning
- Justification of thinking
- Writing about mathematics
- Problem-solving approach to instruction
- Content integration
- Use of calculators and computers

DECREASED ATTENTION

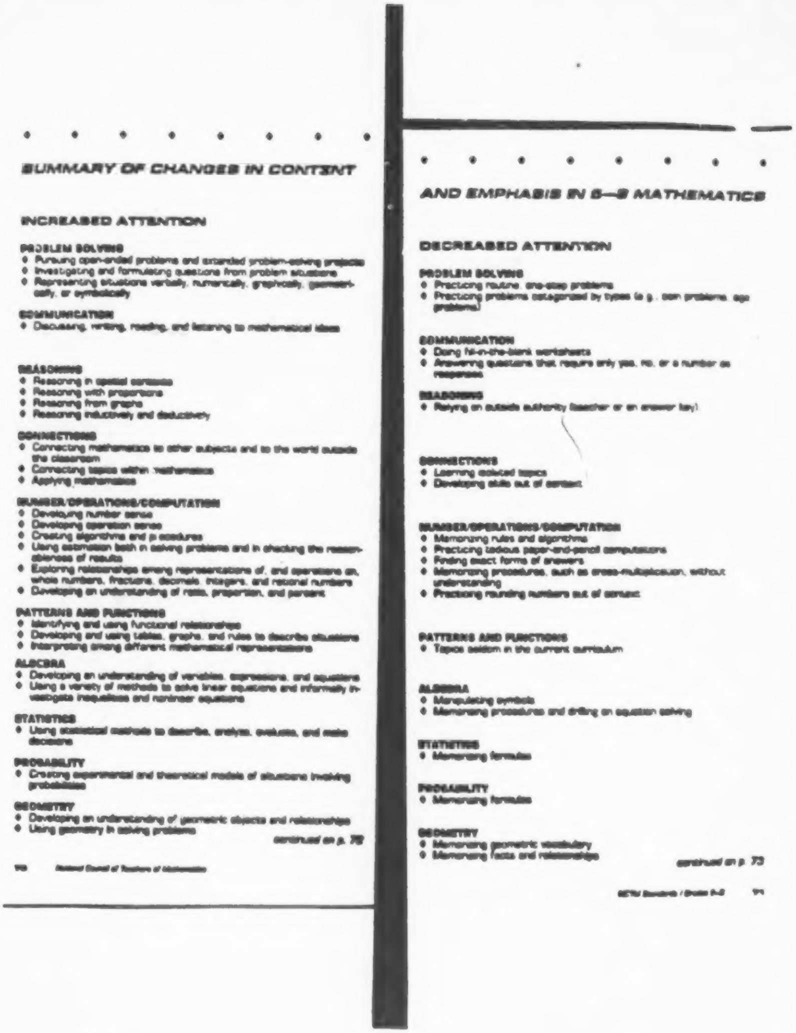
NUMBER
- Early attention to reading, writing, and ordering numbers symbolically

OPERATIONS AND COMPUTATION
- Complex paper-and-pencil computations
- Isolated treatment of paper-and-pencil computations
- Addition and subtraction without renaming
- Isolated treatment of division facts
- Long division
- Long division without remainders
- Paper-and-pencil fraction computation
- Use of rounding to estimate

GEOMETRY AND MEASUREMENT
- Primary focus on naming geometric figures
- Memorization of equivalencies between units of measurement

PROBLEM SOLVING
- Use of clue words to determine which operation to use

INSTRUCTIONAL PRACTICES
- Rote practice
- Rote memorization of rules
- One answer and one method
- Use of worksheets
- Written practice
- Teaching by telling



SUMMARY OF CHANGES IN CONTENT AND EMPHASIS IN 5–8 MATHEMATICS

INCREASED ATTENTION

PROBLEM SOLVING
- Pursuing open-ended problems and extended problem-solving projects
- Investigating and formulating questions from problem situations
- Representing situations verbally, numerically, graphically, geometrically, or symbolically

COMMUNICATION
- Discussing, writing, reading, and listening to mathematical ideas

REASONING
- Reasoning in spatial contexts
- Reasoning with proportions
- Reasoning from graphs
- Reasoning inductively and deductively

CONNECTIONS
- Connecting mathematics to other subjects and to the world outside the classroom
- Connecting topics within mathematics
- Applying mathematics

NUMBER/OPERATIONS/COMPUTATION
- Developing number sense
- Developing operation sense
- Creating algorithms and procedures
- Using estimation both in solving problems and in checking the reasonableness of results
- Exploring relationships among representations of, and operations on, whole numbers, fractions, decimals, integers, and rational numbers
- Developing an understanding of ratio, proportion, and percent

PATTERNS AND FUNCTIONS
- Identifying and using functional relationships
- Developing and using tables, graphs, and rules to describe situations
- Interpreting among different mathematical representations

ALGEBRA
- Developing an understanding of variables, expressions, and equations
- Using a variety of methods to solve linear equations and informally investigate inequalities and nonlinear equations

STATISTICS
- Using statistical methods to describe, analyze, evaluate, and make decisions

PROBABILITY
- Creating experimental and theoretical models of situations involving probabilities

GEOMETRY
- Developing an understanding of geometric objects and relationships
- Using geometry in solving problems

continued on p. 72

DECREASED ATTENTION

PROBLEM SOLVING
- Practicing routine, one-step problems
- Practicing problems categorized by types (e.g., coin problems, age problems)

COMMUNICATION
- Doing fill-in-the-blank worksheets
- Answering questions that require only yes, no, or a number as responses

REASONING
- Relying on outside authority (teacher or an answer key)

CONNECTIONS
- Learning isolated topics
- Developing skills out of context

NUMBER/OPERATIONS/COMPUTATION
- Memorizing rules and algorithms
- Practicing tedious paper-and-pencil computations
- Finding exact forms of answers
- Memorizing procedures, such as cross-multiplication, without understanding
- Practicing rounding numbers out of context

PATTERNS AND FUNCTIONS
- Topics seldom in the current curriculum

ALGEBRA
- Manipulating symbols
- Memorizing procedures and drilling on equation solving

STATISTICS
- Memorizing formulas

PROBABILITY
- Memorizing formulas

GEOMETRY
- Memorizing geometric vocabulary
- Memorizing facts and relationships

continued on p. 73

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SUMMARY OF CHANGES—continued

INCREASED ATTENTION

MEASUREMENT
- Estimating and using measurement to solve problems

INSTRUCTIONAL PRACTICES
- Actively involving students individually and in groups in exploring, conjecturing, analyzing, and applying mathematics in both a mathematical and a real-world context
- Using appropriate technology for computation and exploration
- Using concrete materials
- Being a facilitator of learning
- Assessing learning as an integral part of instruction

DECREASED ATTENTION

MEASUREMENT
- Memorizing and manipulating formulas
- Converting within and between measurement systems

INSTRUCTIONAL PRACTICES
- Teaching computations out of context
- Drilling on paper-and-pencil algorithms
- Teaching topics in isolation
- Stressing memorization
- Being the dispenser of knowledge
- Testing for the sole purpose of assigning grades

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SUMMARY OF CHANGES IN CONTENT AND EMPHASES IN 9–12 MATHEMATIC

TOPICS TO RECEIVE INCREASED ATTENTION

ALGEBRA
- The use of real-world problems to motivate and apply theory
- The use of computer utilities to develop conceptual understanding
- Computer-based methods such as successive approximations and graphing utilities for solving equations and inequalities
- The structure of number systems
- Matrices and their applications

GEOMETRY
- Integration across topics at all grade levels
- Coordinate and transformation approaches
- The development of short sequences of theorems
- Deductive arguments expressed orally and in sentence or paragraph form
- Computer-based explorations of 2-D and 3-D figures
- Three-dimensional geometry
- Real-world applications and modeling

TRIGONOMETRY
- The use of appropriate scientific calculators
- Realistic applications and modeling
- Connections among the right triangle ratios, trigonometric functions, and circular functions
- The use of graphing utilities for solving equations and inequalities

FUNCTIONS
- Integration across topics at all grade levels
- The connections among a problem situation, its model as a function in symbolic form, and the graph of that function
- Function equations expressed in standardized form as checks on the reasonableness of graphs produced by graphing utilities
- Functions that are constructed as models of real-world problems

STATISTICS

PROBABILITY

DISCRETE MATHEMATICS

• • • • • • • •

TOPICS TO RECEIVE DECREASED ATTENTION

ALGEBRA
- Word problems by type, such as coin, digit, and work
- The simplification of radical expressions
- The use of factoring to solve equations and to simplify rational expressions
- Operations with rational expressions
- Paper-and-pencil graphing of equations by point plotting
- Logarithm calculations using tables and interpolation
- The solution of systems of equations using determinants
- Conic sections

GEOMETRY
- Euclidean geometry as a complete axiomatic system
- Proofs of incidence and betweenness theorems
- Geometry from a synthetic viewpoint
- Two-column proofs
- Inscribed and circumscribed polygons
- Theorems for circles involving segment ratios
- Analytic geometry as a separate course

TRIGONOMETRY
- The verification of complex identities
- Numerical applications of sum, difference, double-angle, and half-angle identities
- Calculations using tables and interpolation
- Paper-and-pencil solutions of trigonometric equations

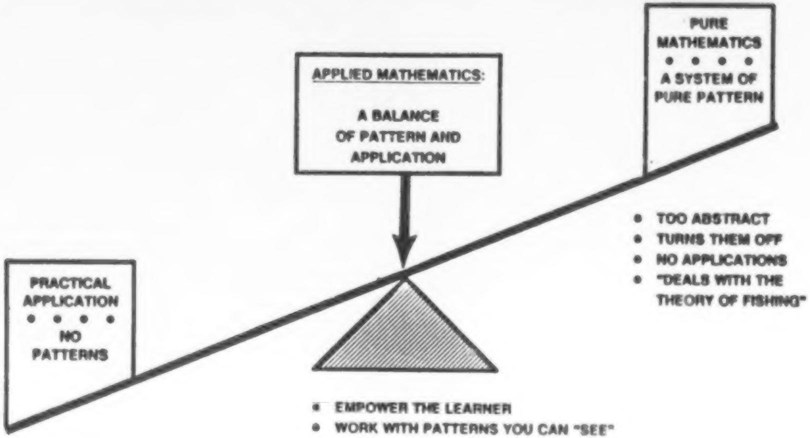
FUNCTIONS
- Paper-and-pencil evaluation
- The graphing of functions by hand using tables of values
- Formulas given as models of real-world problems
- The expression of function equations in standardized form in order to graph them
- Treatment as a separate course

Instructional Design
for

Applied Mathematics

CENTER FOR OCCUPATIONAL RESEARCH AND DEVELOPMENT

THE ROLE OF APPLIED MATHEMATICS



PRACTICAL APPLICATION
• • • •
NO PATTERNS

- CAN'T GENERALIZE
- TOO FRAGMENTED
- DOESN'T EQUIP THEM TO SOLVE PROBLEMS
- "CLEANING AND COOKING FISH"

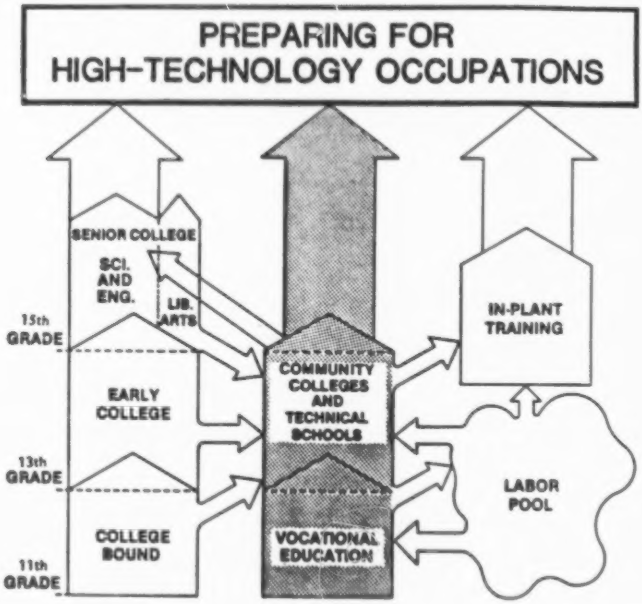
APPLIED MATHEMATICS:

A BALANCE OF PATTERN AND APPLICATION

- EMPOWER THE LEARNER
- WORK WITH PATTERNS YOU CAN "SEE"
- "TEACH THEM HOW TO FISH"

PURE MATHEMATICS
• • • •
A SYSTEM OF PURE PATTERN

- TOO ABSTRACT
- TURNS THEM OFF
- NO APPLICATIONS
- "DEALS WITH THE THEORY OF FISHING"


PREPARING FOR
HIGH-TECHNOLOGY OCCUPATIONS
SENIOR COLLEGE
SCI. AND ENG.
LIB. ARTS
15th GRADE
EARLY COLLEGE
13th GRADE
COLLEGE BOUND
11th GRADE
COMMUNITY COLLEGES AND TECHNICAL SCHOOLS
VOCATIONAL EDUCATION
IN-PLANT TRAINING
LABOR POOL

ADVANCED TECHNOLOGY CAREERS FOR TECHNICIANS

- COMPUTERS
- TELECOMMUNICATIONS
- COMPUTER-AIDED DESIGN
- ROBOTICS / AUTOMATED MANUFACTURING
- INTELLIGENT BUILDINGS
- INSTRUMENTATION AND CONTROL
- LASERS
- BIOTECHNOLOGY
- AUTOMOTIVE TECHNOLOGY

The 25 Units That Make Up Applied Mathematics

Unit	Title
PREPARATORY UNITS	
A	Getting to Know Your Calculator
B	Naming Numbers in Different Ways
C	Finding Answers with Your Calculator
APPLIED MATH UNITS	
1	Learning Problem-solving Techniques
2	Estimating Answers
3	Measuring in English and Metric Units
4	Using Graphs, Charts and Tables
5	Dealing with Data
6	Working with Lines and Angles
7	Working with Shapes in Two Dimensions
8	Working with Shapes in Three Dimensions
9	Using Ratios and Proportions
10	Working with Scale Drawings
11	Using Signed Numbers and Vectors
12	Using Scientific Notation
13	Precision, Accuracy, and Tolerance
14	Solving Problems with Powers and Roots
15	Using Formulas to Solve Problems
16	Solving Problems That Involve Linear Equations
17	Graphing Data
18	Solving Problems That Involve Nonlinear Equations
19	Working with Statistics
20	Working with Probabilities
21	Using Right-triangle Relationships
22	Using Trigonometric Functions

V. USING THE MATERIALS

The sequence of events for delivering a typical unit of Applied Mathematics is as follows:

PRETEST

MOTIVATION

- Video introduces unit concept, presents typical applications and role models, and poses a problem.
- Class participates in solution of problem from video.
- Teacher elaborates on unit concept presented in video.

COMPREHENSION

- Teacher and students encounter mathematics material in unit.
- Teacher presents mathematics material, with emphasis on applications.
- Students read printed material and work through text examples.

APPLICATIONS

- Students apply problem-solving techniques to text problems, both general and occupationally specific.
- Students work in groups on laboratory activities associated with mathematics concepts.
- Students use calculators for computation.

REVIEW

- Class reviews unit objectives.
- Class reviews problem-solving strategies used.

POST-TEST

LEARNING MATERIAL COMPONENTS FOR EACH UNIT OF APPLIED MATH

STUDENT TEXT

- VIDEO TAPE ~ 10 MINUTES
- MATH CONTENT / TEXT ~ 30 PP
- MATH LAB ACTIVITY
  - THREE TO CHOOSE FROM
  - EACH DESIGNED FOR ONE 45-MIN SESSION
- PROBLEM-SOLVING
  - 5 GENERAL PROBLEMS
  - 35 OCCUPATIONALLY-SPECIFIC PROBLEMS (AGRICULTURE / AGRIBUSINESS; HEALTH OCCUPATIONS; HOME ECONOMICS; BUSINESS AND MARKETING; INDUSTRIAL TECHNOLOGY)
- REFERENCE MATERIAL
  - GLOSSARY
  - UNIT CONVERSION TABLES
  - INSTRUCTIONS FOR DRAWING KIT

HISTORY OF THE NORM-REFERENCED ACHIEVEMENT TESTING PROGRAM

As a result of the Comprehensive Education Reform Act of 1984, the State of Tennessee mandated that a nationally normed, standardized achievement test be administered to all public school students in grades 2, 5, and 7. Following an extensive review process which involved a statewide committee of educators, the Stanford Achievement Test (SAT), 7th edition (1982), was selected as the appropriate test. The SAT has a reputation for excellence and is used throughout the country.

Description of the Stanford Achievement Test

The Stanford Achievement Test is a standardized, nationally normed test. The scores indicate how the achievement of Tennessee students compares with that of students at the same grade level nationwide. The SAT uses multiple-choice questions and specific time limits. Subject areas currently tested are Reading, Mathematics, Language, Science, Social Science, and Listening. A breakdown follows of the subtests used to assess student achievement in each of these subject areas at each grade level.

STANFORD ACHIEVEMENT TEST SUBTESTS
BY SUBJECT AREA AND GRADE LEVEL
SPRING 1988

Subject Area	Grade Level		
	2	5	7
Reading	Rdg. Comprehension Word Study Skills Word Reading	Rdg. Comprehension Word Study Skills	Rdg. Comprehension
Mathematics	Concepts of Number Math Computation Math Applications	Concepts of Number Math Computation Math Applications	Concepts of Number Math Computation Math Applications
Language	Spelling	Spelling Language	Spelling Language
Science	Environment	Science	Science
Social Science		Social Science	Social Science
Listening	Listening Comp. Vocabulary	Listening Comp. Vocabulary	Listening Comp. Vocabulary

NOTE: Reading at the 7th grade level consists only of Reading Comprehension, Language at the 2nd grade level consists only of Spelling, and Environment combines Science and Social Science at grade 2.

STANFORD ACHIEVEMENT TEST RESULTS
SPRING, 1988

The Stanford Achievement Test (1982 Edition)* was administered to 61,373 students in grade 2; 60,011 students in grade 5; and 59,925 students in grade 7. The number of students reported in the tables and charts which follow will be less than the number of students who were administered the tests. The decrease is due to the exclusion criteria which excludes from summary statistics students coded handicapped options of service 7-9, those handicapped students receiving test modifications, and those limited English proficiency students who scored less than 3.5 on the Language Assessment Battery or less than 15 on the Teacher Judgment Form. The exclusion criteria used this year remained unchanged from last year.

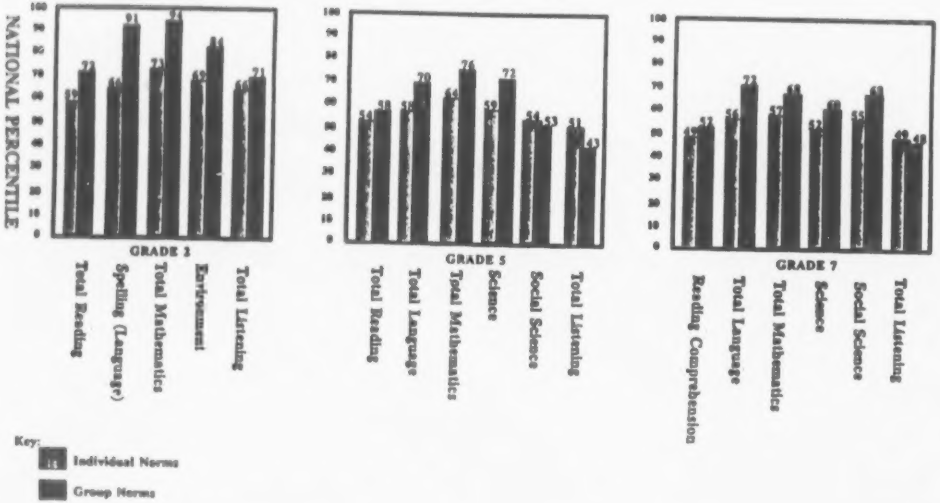
A change in reporting summary data to school systems was instituted this current school year. For the past three years, summary data were reported to school systems based on group norms. This current school year, summary data were reported to school systems based on both individual and group norms. A brief description of these two norming techniques follows:

> **Group Norms** are a measure of how the average score of a collection of students contained in a classroom, school, or system (a unit) compares with the average score of either small (enrollment equal to or less than 50 per grade) or large (enrollment greater than 50 per grade) schools across the nation, whichever most closely matches the size of the unit. This has been the method of reporting unit scores for the past three years in the testing of students in the second, fifth, seventh, ninth, and twelfth grades. This technique of Norming has also been used in all other grades for the Stanford Achievement Test since the spring of 1986.
>
> **Individual Norms** are a measure of how an individual student compares with all students in the nation. This method is also used to compare units by comparing the average student of that unit with all students in the nation. This is the method of comparison used most frequently in testing programs and has been used in all other norm-referenced testing done by State Testing.

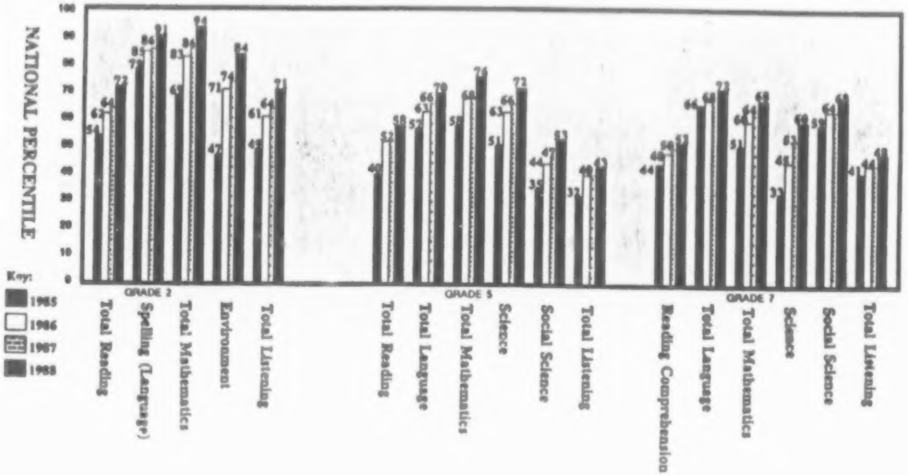
Bar graphs and charts on the following pages summarize 1987-88 results and compare this year's results with previous years. Data dealing with only the 1987-88 school year are based on both individual and group norms. Comparison data, from year to year, are based on group norms.

**The Test Norms Used to Prepare this Report are Part of the Stanford Achievement Testing Series, 1982 Edition © 1983.*

STANFORD ACHIEVEMENT TEST
STATEWIDE RESULTS
SPRING 1988



STANFORD ACHIEVEMENT TEST
STATEWIDE RESULTS*
SPRING 1985 – 1988 COMPARISON



*Based on Large Group Norms

Computer Education In Tennessee

Computer Education in the State of Tennessee began with the meeting of a computer curriculum committee in early 1982. The committee developed a curriculum to be used in grades K - 12 to teach computer skills.

As part of the Better Schools Program, the Computer Skills Next (CSN) Program was instituted. This program is designed to help the state's seventh and eighth graders become computer literate and prepare them to progress to more advanced computer science courses in high school.

The Computer Skills Next courses consists of fifteen lessons at each grade level dealing with computer operations, programming, and applications. These lessons are flexible enough to mesh with the curriculum of any traditional subject area, and to accommodate computer novices, as well as to challenge students with considerable computing experience.

In the Computer Operations section, students learn to identify the components of a microcomputer system, understand their functions, and to operate the computer system. This unit also includes basic keyboarding skills.

The Programming section introduces students to the BASIC programming language. They learn how algorithms work, how to develop flow charts, and how to write short programs in BASIC.

In the Applications sections, students examine the use of computers in schools, homes, and various professions. Students are exposed to word processing, data base management, and the use of spreadsheets.

In support of the program, the teachers selected to teach the computer literacy courses in the state's junior high schools attended an intensive five day training workshop for each grade level they were to teach. Training continues each year as new teachers are assigned the responsibility of teaching the Computer Skills Next courses.

Additional support services were given in the form of:

- * $500 for each school to purchase instructional software
- * A toll-free hotline for teachers needing assistance
- * A consultant for each of the state's regional educational service centers
- * Membership in educational computing organizations

While the CSN program was being implemented in the seventh and eighth grades, work was begun on creating lessons for other grade levels. A program for fifth and sixth grades was started. They consist of twelve lessons in the fifth grade and fifteen lesson in the sixth grade. The use of these lessons is voluntary.

The State Board of Education added courses for grades 9 - 12. These courses fall under two categories: Business Education and Computer Technology. Teachers who are teaching these lessons must meet employment standards established by the board in order to teach these courses.

The Business Education courses are:

- BASIC I
- BASIC II
- Personal Computing
- Software Tools

The Computer Technology courses are:

- FORTRAN
- Pascal I
- Pascal II
- Advanced LOGO
- Advanced Placement Computer Science

A task force of teachers have met and designed an activity guide for grades K - 4. These lessons are presently being piloted in several schools across the state. Hopefully, by this fall they will be ready for use by all schools.

The Office of Computer Education, David Wooten-Director, Jim Oakes-East Tennessee, Morgan Branch-Middle Tennessee, Phillip White-West Tennessee, and Betty Latture-MECC, is available to help your school in implementing the curriculum in Computer Education.

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STATE OF TENNESSEE
DEPARTMENT OF EDUCATION

CERTIFICATION IN COMPUTER TECHNOLOGY

SYSTEM ______________________________

SCHOOL ______________________________

NAME ______________________________

TEACHER NUMBER ______________________________

SOCIAL SECURITY NUMBER ______________________________

CERTIFICATE NUMBER ______________________________

Date of Expiration of Certificate ______________________________

SECONDARY ENDORSEMENTS

____

COURSES IN COMPUTER TECHNOLOGY TO BE TAUGHT

____ Personal Computing

____ Software Tools

____ Data Structures and Language BASIC I

____ Data Structures and Language BASIC II

____ Data Structures and Language PASCAL I

____ Data Structures and Language PASCAL II

____ Data Structures and Language FORTRAN

____ Data Structures and Language LOGO

____ Advanced Placement Computer Science

COURSEWORK COMPLETED IN COMPUTER EDUCATION
(Please describe in detail)

(Must consist of a minimum of 6 semester hours for Personal Computing, Software Tools, BASIC I and BASIC II and 12 semester hours for any course above that level.)

Semester Hours	Course Name	Date Completed	Institution

EMPLOYMENT STANDARDS: (Must be met by the 1988-89 school year)

To teach Personal Computing, Software Tools, BASIC I and BASIC II, the teacher must hold a valid Tennessee teacher's certificate with secondary endorsement(s) and must have completed six semester hours of data processing/computer science to include at least one programming language.

To teach Data Structures & Language Organization/PASCAL I, Data Structures and Language & Organization/PASCAL II, Data Structures and Language Organization/FORTRAN, Data Structures & Language Organization/LOGO, and Advanced Placement Computer Science, the teacher must hold a valid Tennessee teacher's certificate with secondary endorsement(s) and must have completed twelve semester hours to include the following:

- six semester hours of programming, three of which would emphasize a block structured language,
- three semester hours of data structures, and
- three semester hours of another computer science course.

Teacher ____
Signature

Principal ____
Signature

This Portion for State Department Use Only

The above applicant has met the empolyment standards for teaching:

_____ Personal Computing, Software Tools, BASIC I and BASIC II.

_____ Data Structures PASCAL I, II, FORTRAN and LOGO.

Approved ______________________________________ Date _____________
State Department of Education

NOTE: A CERTIFIED TRANSCRIPT FROM THE INSTITUTION GRANTING THE CREDIT MUST BE ATTACHED.

Return Completed Form To:

Office of Computer Education
Tennessee Department of Education
C-1 103 Central Services Building
Nashville, TN 37219
Phone: (615) 741-6206

TEACHER EDUCATION POLICY IMPLEMENTATION

LICENSURE STANDARDS AND INDUCTION GUIDELINES

Tennessee State Board of Education

November 14, 1988

TEACHER EDUCATION POLICY: SUMMARY AND IMPLEMENTATION

Tennessee State Board of Education

November, 1988

Executive Summary

Tennessee is focusing on three areas critical to attracting the best possible individuals into the teaching profession and ensuring that they remain in the profession: competitive salaries, a professional work environment, and improved teacher education programs. The state is making progress in all three of these key areas. Cooperative efforts among K-12 and higher education personnel have been especially productive in the area of teacher education reform. Following almost two years of study, the State Board of Education, the Tennessee Higher Education Commission, and the State Certification Commission in January, 1988, adopted a new Teacher Education Policy.

Restructured teacher education programs in Tennessee will have a curriculum consisting of a comprehensive general education core, an academic major, and a focused professional education core. This basic academic preparation will be designed in conjunction with early "hands-on" teaching experiences in schools. A one-year internship or full semester enhanced student teaching will strengthen the practical experience of teachers. Teacher candidates who undertake enhanced student teaching will also have a beginning teacher program to support them during their first year of employment. The policy will also encourage qualified college graduates who have no prior teacher preparation to enter the profession through post-baccalaureate programs. The new policy will be phased in over the next eight years to provide an opportunity to test the effectiveness of the internship, enhanced student teaching, beginning teacher, and post-baccalaureate programs.

Throughout the new Teacher Education Policy is an increased emphasis on the partnership between local school systems and institutions of higher education. Mentor teachers and principals in local schools will play a key role in determining the practical skills needed by teacher candidates. Faculty from institutions of higher education will spend increased time in schools working with teacher candidates and assisting mentor teachers.

The first phase of implementation -- developing competency standards for licensure, guidelines for induction, new program approval standards, and a program for recruiting well qualified students, especially minority students -- is underway. On November 18, 1988, the State Board of Education, in consultation with the Commissioner of Education and the Tennessee Higher Education Commission approved implementation recommendations from the Advisory Council on Teacher Education and Certification in two areas: (1) licensure standards and (2) induction guidelines.

The Process

The Advisory Council on Teacher Education and Certification, appointed by the State Board of Education, was charged with the task of fashioning a set of recommended standards and guidelines for the implementation of the new Teacher Education Policy. The Advisory Council organized a number of ad hoc committees involving more than 150 individuals to assist in this process. As each of the ad hoc committees completed its work, the Advisory Council took preliminary action and distributed draft recommendations statewide for comment prior to making its final recommendations to the State Board of Education.

In June, 1988, and again in September, 1988, the Advisory Council distributed statewide recommendations in two areas, (1) licensure standards and (2) induction guidelines. The public commented on the final recommendations through a series of nine public forums held October 10-24 and by contacting directly the Advisory Council staff. The final implementation recommendations incorporate many of the suggestions received.

Draft recommendations for other areas of initial licensure (special education, occupational education, physical education, and health) are being developed along with procedures for approval of teacher education programs and evaluation of teacher candidates and teacher education programs. These recommendations will be distributed for comment during 1988-89 the school year.

What follows is an outline of the policy. Progress toward implementation in each area is noted by an asterisk.

Recruitment, Admission, and Retention of Teachers

Tennessee like other states must attract well qualified and committed individuals to the teaching profession. Competitive salaries, improved working conditions, and strengthened teacher preparation programs will stimulate greater interest in teaching as a career. However, other actions are also needed if colleges/universities are to prepare a larger number of well qualified beginning teachers for our schools.

The Teacher Education Policy specifies the following goals: increase the number of academically talented students who enter teacher education; increase the number of minorities, especially blacks, who enter teacher education; ensure an adequate distribution of prospective teachers across subject areas; and increase the pool of teacher education students who show evidence of commitment to teaching and to the development of children and young people.

* The Advisory Council developed recommendations regarding admission to teacher education programs; the recommendations were approved by the State Board of Education on September 30, 1988.

- The Minority Teacher Task Force has proposed a series of bold strategies for recruiting and retaining minority teachers.

Curriculum

All prospective teachers will complete an enhanced curriculum developed by institutions of higher education and consisting of three components: a general education core, a professional education core, and an academic major. The general education core curriculum will constitute approximately 50% of the 120 semester hour minimum required for a baccalaureate degree. The major, an integrated, sequential program of study, will constitute no more than 30% of the curriculum. The professional education core will comprise the rest of the curriculum and will incorporate recent research on teaching and learning.

Institutions of higher education are responsible for developing the major and organizing the course work, which is to be taught primarily by faculty in arts and sciences disciplines or by other faculty for vocational areas. Teacher candidates will have adequate advisement in both professional education and the major.

Licensure

New licensure standards in the three curriculum components will be based on knowledge and skills expected of teachers seeking initial licensure. The knowledge and skills were developed by ad hoc committees including 150 educators from local school systems and institutions of higher education.

- The knowledge and skills are set forth in the new licensure standards. Other licensure areas and the standards for add-on endorsements will be addressed in the coming year.

Colleges and universities will have the responsibility to design programs of study for the attainment of the knowledge and skills by teacher candidates. New forms of teacher candidate assessment will need to be developed.

- The Advisory Council's ad hoc committee on evaluation is considering several approaches for assessment of teacher candidates.

Induction into the Profession

The policy calls for strengthening the practical experience of teacher candidates. Teacher candidates will undertake either (1) a one-year, paid internship following the attainment of the baccalaureate degree, or (2) an enhanced student teaching experience of a full semester as part of the undergraduate program followed by a beginning teacher program to provide support to the new teacher during the first year of employment. Both concepts will be piloted and carefully evaluated before a decision is made as to which approach(es) are appropriate for Tennessee. Each of these new programs anticipate a new partnership between institutions of higher education and local school systems.

The policy also calls for the development of post-baccalaureate teacher education programs to prepare highly qualified candidates who already hold baccalaureate degrees but have not previously completed teacher preparation. Teacher candidates must demonstrate the knowledge and skills outlined in the new curriculum and complete an induction experience comparable to that required of other candidates. These programs will also be piloted and evaluated.

- Guidelines for internship, enhanced student teaching, beginning teacher programs, and post-baccalaureate programs were approved by the State Board of Education on November 18, 1988.

Teacher Education Program Approval

Procedures for approval of teacher education programs will include two processes by which institutions of higher education may gain state approval. Approval will be based either upon NCATE accreditation or comparable state standards. State approval is also a part of the NCATE approval process. Approved programs must ensure that teacher candidates have opportunities to attain the specified knowledge and skills, have internship or student teaching experiences, and meet other guidelines established by the State Board of Education.

Continuing approval of a teacher education program will be based upon (1) continuing NCATE accreditation or state approval, (2) the performance of an institution's graduates, and (3) evidence that the institution is evaluating the performance of its graduates and using this information to improve its programs.

- The Advisory Council's ad hoc committee on program approval is developing procedures to accomplish the new methods of approving teacher education programs.
- This committee is also addressing the issue of improving reciprocity between Tennessee and other states for teachers.

Funding

State funding will include financial support for induction pilots. In the internship pilots, interns will receive a stipend and mentor teachers will use released time and/or receive compensation for work with interns. In enhanced student teaching pilots, cooperating teachers will receive compensation for supervision of student teachers. In the beginning teacher program pilots, mentor teachers will use released time and/or receive compensation.

Funding mechanisms for institutions of higher education will be reviewed regarding financial support for (1) the assignment of faculty to internship programs, enhanced student teaching programs, and other off-campus activities in schools, (2) institutional performance incentives for improved teacher education programs, and (3) incentives to attract well qualified teacher candidates, especially black teacher candidates.

Implementation and Evaluation

Implementation of the new Teacher Education Policy is well underway. The new policy will be phased in over the next eight years in order to provide an opportunity to test the effectiveness of the induction models. New licensure standards will be implemented beginning in fall 1990. Candidates must meet the new curriculum standards beginning with those who complete course work in spring 1994. Program approval will be based upon the new standards beginning in fall 1990. Institutions wishing to meet the new standards earlier than these dates will be encouraged to do so. Plans for other licensure areas will be developed and adequate time will be allowed for planning and phase-in for students already enrolled.

The induction model pilots will be implemented beginning fall 1989-90 and will be evaluated continuously. In 1995-96 the total plan will be evaluated and decisions made regarding which approach(es) to induction are appropriate for continued or expanded implementation.

- The Advisory Council's ad hoc committee on evaluation is developing guidelines for this total plan evaluation.

Courses to meet various entrance Requirements:

Discipline	Honors Diploma (General Education)	Units	Board of Regents (All state schools except UT)	Units	Board of Trustees (UT System schools)	Units
English	English		English		English	
	Total	4	Total	4	Total	4
Mathematics	Algebra, Geometry or above	2 1	Algebra, Geometry and above	2 1	Algebra, Geometry or above	2 1
	Total	3	Total	3	Total	3
Science	Biology, Chemistry, Physics Science elective	2 1	Biology, Chemistry or Physics Science elective	1 1	Biology, Chemistry, or Physics Science elective	1 1
	Total	3	Total	2	Total	2
Social Studies	U.S. History Economics Social Studies elective	1 .5 1.5	U.S. History History, Government, Geography, Sociology, Psychology, Economics or Anthropology	1 1	U.S. History European or World History or World Geography	1 1
	Total	3	Total	2	Total	2
Foreign Languages	One Language	2	One Language	2	One Language	2
	Total	2	Total	2	Total	2
Fine Arts	Fine Arts elective	2	Visual or Performing Arts	1	Fine Arts	0
	Total	2	Total	1	Total	0
Health and Physical Education	Health Education, Physical Education	.5 1	Health Education, Physical Education	0 0	Health Education Physical Education	0
	Total	1.5	Total	0	Total	0

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Ms. **Lloyd**. Dr. Farmer, we certain appreciate your insight, your ability and your excellent presentation. All three of you are excellent witnesses. I also took note of your suggestion of tuition free refresher programs for our teachers so they can go back to school and enhance their skills. That is a point well taken.

Do you believe that the basic science requirements, Dr. Farmer, are adequate for teachers today at the elementary level? I am rather disturbed that perhaps our elementary teachers are not getting a sufficient background in the sciences.

Dr. **Farmer**. Do I personally think they are adequate?

Ms. **Lloyd**. Yes.

Dr. **Farmer**. If I had had my way they would have been stronger, but I did not. We, however, have new standards that are being implemented. And whether they are adequate or not will depend upon the interpretation of the colleges. As I understand the new standards, each college that has a teacher training program will determine how to implement those standards. The framework is definitely there to have a strong science program, but it is written to where it depends on the interpretation of the college.

Ms. **Lloyd**. Are education majors required to take more science perhaps than a liberal arts or a business major?

Dr. **Farmer**. We will not have education majors, as I understand it, at the high school level. Is that where you mean, the 9 through 12 program?

Ms. **Lloyd**. Yes, uh-huh.

Dr. **Farmer**. There will not be education majors with the new standards. They will have to major in a discipline.

Ms. **Lloyd**. They major in a discipline.

Dr. **Farmer**. Yes, rather than education.

Ms. **Lloyd**. Ms. Brown, looking at your—listening to your testimony, what is the degree of interest in science in your students? Do they come to you excited or is this something that you have to instill? Is this something that you have to require—that you have to instill?

Ms. **Brown**. It varies a great deal. We do have some students who come who are interested, but the majority are not.

Ms. **Lloyd**. Is this an inquisitive mind or is it parents that are better than average in instilling love of education in their students or is it television?

Ms. **Brown**. I do not know, I am sorry, I cannot answer you.

Ms. **Lloyd**. I would like to ask all three of you what we could do to help generate interest in science and math in the K through 6 area.

Mr. **Rogers**. I would like to try and answer that if you do not mind. My own view of that is, using another anecdotal comment, is pretty colors and loud noises and bad smells. That is kind of what fires kids up, that keeps them interested. It may sound very trite, but those kinds of things that any individual can do to try and instill that excitement or just keep it going. By the time we get them at the high school level, if it is not there we are not likely to rekindle it. So if you take—someone mentioned earlier today those three year olds and four year olds that are still filled with the wonderment of everything that is around them and somewhere early on in their educational career they lose that. I like to think that rather than our killing that interest in them, that we force its replacement with our emphasis on other things.

Getting back to some of my comments earlier about the national agenda, that thing that is attracting most attention these days, one among many I guess is the deficit. We are losing our kids to MBAs and that sort of thing. And they are buying—people are buying their contributions to the human race, as it were, and we do not have the—something like the work ethic that indicates that people have a responsibility to the rest of the human race to try and do things to make it better along the lines of the sciences, not to say that we are becoming a devoid people or anything like that, but science is just not the place that people are choosing to make their contribution. One of those reasons being there is no money in it.

Again, let me re-emphasize, elementary school kids, we need to deal with them and I think that we need to better prepare our elementary school teachers in whatever way we have to do it.

Ms. Lloyd. Thank you very much. Mr. Schiff.

Mr. Schiff. Mr. Rogers, I hate to say it, but there is not a lot of money in being in Congress. Hopefully we are making a contribution.

Actually, Madam Chair, I just thoroughly enjoyed the testimony from all three witnesses. I am very interested in the promotion of education, particularly scientific education and I am pleased to hear from three outstanding educators. Really there is nothing more I could add or ask. Thank you.

Ms. Lloyd. Ms. Brown, Mr. Rogers, Dr. Farmer, we thank all three of you for your input and your insight and thank you also for caring about our young people. That is so important to us.

Our last panel may be the most exciting because these three witnesses are the current students that are participating in the DOE lab programs at Oak Ridge National Laboratory. Jennifer Ethridge is studying mathematics at Roanoke College and I have here that Jennifer lives in the Third District in Oak Ridge. Next we have Teresa Kowalski, a geology major who just graduated from the University of Pennsylvania and will start graduate school at Arizona State University in the fall. And Miguel Rodriguez is a microbiology student from the University of Puerto Rico. We thank all three of you for being here. Ms. Ethridge, will you begin?

Panel 5

STATEMENTS OF JENNIFER A. ETHRIDGE, STUDENT; TERESA E. KOWALSKI, STUDENT AND MIGUEL RODRIGUEZ-VELEZ, STUDENT

Ms. Ethridge. They were obviously right before when they were talking about the Levis, this is how I went to work this morning.

Actually I want to apologize first for coming so unprepared, because I did not know for certain until this morning that I would be here. When I was asked to come make this statement, I was a little hesitant because—well I will cover that later and I think you will understand my hesitancy when I continue. Like I say, I did not decide until this morning that I would be here

To introduce myself briefly, I am a junior at Roanoke College in Salem, Virginia and I graduated from Oak Ridge High School in Oak Ridge, Tennessee. My calculus teacher, Juanita Albert, was one of the main influences upon my decision to become a math major. I never met a teacher like her before and I have not since and I do not expect to. She is the type who can make learning math almost fun. If I try to describe her, I do not know how. She is almost eccentric and I think that is important. Like you were saying before like the boom and the colors and everything. You need personality in your teachers, because no matter how much a teacher knows, if they do not have the personality, then kids are not going to pay attention. And Ms. Albert had the personality and the knowledge.

So I am a math major. It is just something that I have done for so long, I cannot imagine not doing it. Math is something that I am naturally able to do well and I also find it fascinating. But I also have another major, philosophy and religion. This is actually where my heart is and this is not just something I do, this is what I want to do and this is why I was a little hesitant to come because I was not sure how related it would be.

I thought it would be very unlikely for me to find a summer job or internship in philosophy or religion, so I fell back on my math. I had never thought to work through ORAL before, frankly I am not sure I had ever heard of it, but until last fall when he decided to work in the private sector my father worked for ORNL and it was his idea that I should try to work there for one summer. So last summer I did, but I worked directly for ORNL, I was what they call a junior student trainee which basically meant that I was out there to learn and they did not expect much from me tangibly.

I worked under Dr. Mike Heath in the Engineering Physics and Mathematics Division at Y-12. I had no idea what to expect, no idea what I would be doing, but I did expect that computers would be involved in some way. Not only were they involved in some way, my whole summer was spent facing the computer trying to coax it into drawing pretty pictures for me. My project was to write a program using sun tools on a sun work station, to draw a graphic animation of parallel algorithms. It took all summer for me to figure that out—it took a little while for me to figure out what they were talking about.

I certainly did learn a lot. I had to learn how to use the UNIX system, how to program in C, to use a sun work station and finally to use the sun tool graphics. I came with no experience or knowledge of computers or programming beyond a computer science 101 course.

Much to my surprise, I did accomplish the goal and write the program. It makes a fun demonstration with lots of circles and lines blinking off and on. It was a nice feeling to watch that and know that I had done it, but I was not sure whether the struggle and frustration I had gone through were worth it. Nevertheless, I thought I would do it again this summer and Mike suggested that I apply to ORAL. I did, was accepted and assigned again to Engineering, Physics and Mathematics with Mike as my supervisor. And I just began last Monday.

At the moment I am learning to use the X-window system and I will rewrite the program that I wrote last summer this time using X instead of sun. And beyond that, I am not real sure about what I will be working on except that I know it will involve graphics and it will involve the X tools.

This summer will definitely be my last. I plan to go to summer school next year at Roanoke. I want to graduate a semester early, in December of 1990 and then go on to graduate school, hopefully at Duke. I plan to continue studying religion, perhaps philosophy and most likely mathematics. It may take awhile for me to get through but I cannot imagine leaving one of those subjects behind.

I do not expect ever to program again, as much as I have learned from my work and as much as I feel I have accomplished, I will be quite happy leaving it to someone else. I have discovered that computers and I do not get along well and the area in which I am doing my internship is not one in which I would like to be for long. In fact, my long term career goal is to become a novelist. I also plan to teach at the college level.

My dissatisfaction with my work is in no way a reflection on ORAL or ORNL. All the people I have worked with have been very helpful and encouraging and I would recommend the program to any student who has a serious interest in the sciences. It provides a wonderful experience in active research. I simply had little interest in the area of my research.

Thank you.

[The prepared statement of Ms. Ethridge follows:]

Subcommittee on Energy Research and Development
Committee o Science, Space, and Technology
B-374 Rayburn House Office Building
Washington, D.C. 20515

Jennifer Ann Etheridge
113 Elliott Circle
Oak Ridge, Tn 37830

My testimony will be in the form of a personal account. I will begin with a brief introduction of myself as a student and proceed to give an account of how I came to where I am now, where that is and where I would like to go from here.

I am a junior at Roanoke College in Salem, Va. I graduated from Oak Ridge High School in Oak Ridge, TN in June of 1987. My calculus teacher, Juanita Albert, was one of the major influences upon my decision to become a math major. I had never met a teacher like her before and have not since. I do not expect to. She is the kind of teacher who can make learning math (almost) fun.

So, due to the influences of Mrs. Albert and my father, who received his degree in Mathematics, and my advanced placement (when I entered Roanoke, I was already a third of the way through the major) I now have a major in math. It is something that I have been doing for so long that I can not imagine not doing it. I am naturally able to do it well and I also find it fascinating (especially when I come up with the right answer.)

But I also have another major, Philosophy/Religion. This is where my heart is. This is not just something I do but what I want to do. However, I thought it would be very unlikely for me to find a summer job or internship in Philosophy or Religion (especially one that would pay well.) So I fell back on my math.

I had never thought to apply to ORAU (Oak Ridge Associated Universities.) Frankly, I am not sure I had heard of it. But until last Fall, when he decided he wanted to work in thne private sector, my father worked at ORNL (Oak Ridge National Laboratory.) It was his idea that I should try working at the plants for a summer. So last summer I did. I worked for ORNL as a junior student trainee, which basically meant that I was out ther to learn and they really expected little from me that could be of use to them (in other words, it was looked upon as a community service on their part.) I worked under Dr. Mike Heath in the Engineering Physics and Mathematics division at Y-12. I had no idea what to expect, no idea what I would be doing. But I did suspect that computers would be involved in some way. (Mathematicians often end up in computer science.) Involved in some way! My whole summer was spent facing a computer trying to coax it into drawing pretty pictures for me. My project was to write a program using Suntools on a Sun Workstation to "draw" graphical animation of parallel algorithms. It took all summer for me to figure that out! I certainly did learn quite a bit (no pun intended.) I had to learn how to use the Unix system, to program in C, to use a Sun Workstation and finally to use the Suntool Graphics. I came to the job with no experience or knowledge of computers or programming beyond a computer science 101 course.

Much to my surprise, I accomplished the goal (I have been told that I actually accomplished more than they had expected!) and wrote the program. It makes a fun demonstration with lots of circles blinking off and on and lines being drawn between them. It was a nice feeling to watch that and know that I had done it. But I was not sure whether the struggle and frustration I had gone through were worth it. I had discovered that programming was certainly not my future career. Nevertheless I thought I would do it again this summer. Mike suggested that I apply to ORAU. I did, was accepted, assigned again to EP&M with Mike as my supervisor and began Monday, May 8. At the moment I am learning to use X Windows and XTools and I will rewrite the program using XTools that I wrote last summer using Suntools. Beyond this, I am as yet unsure about the project on which I will be working, thought feel certain that it will involve graphics and XTools.

This summer will definitely be my last at the plants. I plan to go to summer school at Roanoke next year, graduate a semester early, in December of 1990, and go on to graduate school, hopefully at Duke University. I plan to continue studying Religion, perhaps Philosophy and most likely Mathematics. It may take a while but I can not imagine leaving one of then behind. I do not expect ever to program again. As much as I have learned from my work and as much as I feel I have accomplished, I will be quite happy leaving the programming of computers up to someone else. I have discovered that computers and I do not get along well and the area in which I am doing my internship is not one in which I would like to be for long. In fact my long term career goal is to become a novelist. I also plan to teach at the college level.

My dissatisfaction with my work is in no way a reflection on ORAU or ORNL. All of the people I have worked with have been very helpful and encouraging. I would recommend the program to any student who has a serious interest in the sciences. It provides a wonderful experience in active research. I simply have little interest in the area of my research and my placemant in this area was requested.

I hope my testimony will be of help. I enjoyed the opportunity and appreciate the honor. If there are any further questions, I would be glad to answer them and can be reached at home

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Oak Ridge, TN 37830
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until the end of August and at school

Box 469
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Salem, VA 24153

throughout the school year. Thank you.

Ms. LLOYD. Thank you. Teresa.

STATEMENT OF TERESA E. KOWALSKI

Ms. KOWALSKI. As a California——

Ms. LLOYD. You have to get that real close to you, hon.

Ms. KOWALSKI. As a California University of Pennsylvania student, I have had the privilege of participating in the Oak Ridge Associated University internship program, both on an undergraduate and a graduate level.

Ms. LLOYD. Teresa, excuse me, I believe you are going to have to move the microphone in just a little closer.

Ms. KOWALSKI. Okay. Is this better?

As an undergraduate majoring in quantitative geology, I was selected for a chemistry internship by Morgantown Energy Technology Center in Morgantown, West Virginia, due to my diverse scientific and mathematical background. At the graduate level, based on my academic and previous internship performance, I was selected by Martin Marietta Energy Systems for their Hazardous Waste Remedial Actions Program in Oak Ridge, Tennessee to work under the supervision of their chief hydrogeologist.

During my internship at Morgantown, I worked for the Fuel Science Branch under division chiefs John Kovach and Jan Wachter. While working in the Fuel Branch, I conducted research with Dr. Rashid Khan in the mild gasification of coalfields. I took part in research involving the devolatilization of coal, enhancement of liquid fuel from coal tar, uses of coal char as a fuel, processes to minimize caking of coal in reactors, fluidized bed techniques used in the process of mild gasification and the set up and running of an entrained flow reactor for mild gasification of coal and tar recovery.

While working with Dr. Khan, I gained valuable knowledge of laboratory equipment and procedures not accessible to me through the regular college curriculum. Equipment I worked with included the high pressure microdilatometer, thermogravimetric analyzer, slow heating rate organic devolatilization reactor, statistical analyzer systems and the digitizer graphics system. I gained a working knowledge of extraction as well as sample preparation procedures valuable in the professional world. Also during my year's stay at METC, I helped develop a sample drying procedure which is currently in use. I was singularly responsible for inventory, cataloging, sending and receiving of all samples and data information.

I also had the opportunity to attend several seminars and conferences that took place throughout that year. At these functions, I was able to gain information and insight into other aspects of the field of fuel science by hearing reports from others working in related areas. Also during the year, I was tutored in the proper waste disposal techniques, health and safety techniques, and proper sample storage techniques. Some added benefits I received was I had the opportunity to co-author a peer journal paper which was published with me being an undergrad, which is a significant point because most undergrads are not published. It was a really major event in my academic career. Incorporating art work into my job by creating a cartoon for a presentation which was later used by another colleague. And I was certified by the Federal Women's Program for attending a seminar for training.

During my present internship at Oak Ridge, I work for the HAZWRAP group under the supervision of Mark Nickleson, who is our chief hydrologist. The work performed by HAZWRAP involves the management of Air Force base, Air National Guard base and Naval base remediation of potential hazardous waste sites under CERCLA. In addition to working for Mark Nickleson, I also work for Chuck Swinney, who is a project manager on one of the Naval projects in San Diego.

Additional work accomplished thus far includes the learning of PC softwares such as Lotus, Harvard Graphics, Multimate and WordPerfect. I have developed Lotus worksheets for level of effort on tasks for individual sampling tests such as groundwater sampling, that will be implemented for use throughout the program. I also am developing further computer support systems in the Lotus worksheet format which will be also implemented. During my stay I will implement these programs. I have also worked with computer graphics for cover sheets and participated in seminars such as Borehole logging and WordPerfect training and these have been incorporated into my work.

Further activities shall include travel to a site to observe field work. I also plan to attend a preliminary assessment meeting regarding future site activities. I hope to acquire knowledge about procedures for handling site remediation which might in the future be applicable to private remediation as well as the present Federal remediation that is going on.

In closing, I would like to say that these internships have exposed me to both research and development as well as managerial aspects of the applied basic science. I have gained discipline in the laboratory setting through METC and learned an understanding of the need for management of field research through HAZWRAP. From the recognition acquired through these internships, I was offered and have accepted a position at Arizona State University for the fall. Through both internships I have obtained a professional reputation which will benefit me in the acquisition of a career position at a future time. I now, through these internships, possess a professional knowledge and attitude which will be an asset to my career.

Thank you.

[The prepared statement of Ms. Kowalski follows:]

To: U.S. House of Representatives
Committee on Science, Space, and Technology
Subcommittee on Energy Research and Development.

From: Teresa E. Kowalski
Participant in Oak Ridge Associated University Internship Programs.

Subject: Testimony on behalf of National Laborotory Internship Programs.

As a California University of Pennsylvania student, I have had the priviledge of participating in the Oak Ridge Associated University Internship Program, both on an undergraduate and graduate level. As an undergraduate majoring in Quantitative Geology, I was selected for a chemistry internship by Morgantown Energy Technology Center (METC) in Morgantown, West Virginia, due to my diverse scientific and mathmatical background. At the graduate level, based on my academic and previous internship performance, I was selected by Martin Mariette Energy Systems, Inc. for their Hazardous Waste Remedial Actions Program (HAZWRAP) in Oak Ridge, Tn., to work under the supervision of the chief Hydrogeologist.

During my internship at Morgantown, I worked for the Fuel Science Branch under division chiefs John Kovach and Jan Wachter. While working in the Fuel Branch, I conducted research with Dr. M. Rashid Khan in the field of Mild Gasification of Coal. I took part in research involving the devolitilization of coal, enhancement of liquid fuel from coal tar, uses of coal char as a fuel, processes to minimize caking of coal in reactors, fluidized bed techniques used in the process of mild gasification, and the set-up and running of an entrained flow reactor for mild gasification of coal and tar recovery

While working with Dr. Khan, I gained vaulable knowledge of laboratory equipment and procedures not accessable to me through the regular college curriculum. Equipment I work with included the High Pressure Microdilatometer (HPMD), Thermogravimeteric analyzer (TGA), Slow Heating Rate Organic Devolitilization Reactor (SHRODR), Statistical Analyzer Systems (SAS), and Digitizer Graphics System. I gained a working knowledge of extraction as well as sample preparation procedures valuable in the professional world. Also during my year's stay at METC, I helped develop a sample drying procedure which is currently in use. I was singularly responsible for inventory, cataloging, sending and recieving of all samples and data information.

I also had the opportunity to attend several seminars and conferences that took place throughout that year. At these functions, I was able to gain information and insight into other aspects of the field of fuel science by hearing reports from others working in related areas. Also during the year, I was tutored in the proper waste disposal techniques, Health and Safety techniques, and proper sample storage techniques. Some added benefits include:

o a co-authorship of a peer journal paper, o incorporating art work into my job by creating a cartoon for a presentation which was later used by another colleague

o certifcation by the Federal Women Program by attending a seminar.

During my present internship at Oak Ridge, I work for the HAZWRAP group under the supervision of Mark Nickleson. The work preformed by HAZWRAP involves the management of Air Force, Air National Guard, and Naval base remediation of potential hazardous waste sites under CERCLA. In addition to working for Mark Nickleson, I also work with Chuck Swinney, a project manager on a project in San Diego.

Additional work accomplished thus far includes the learning of PC softwares (Lotus, Harvard Graphics, Multi-Mate, and Word Prefect). I have developed Lotus worksheets for Level Of Effort on tasks for individual sampling tests (i.e. Groundwater sampling) that will be implemented for use throughout the program. I have also worked with Computer Graphics for cover sheets. Participation in seminars such as Borehole logging and Word Prefect training have been incorporated into my work.

Future activities shall include travel to a site to observe field work. I also plan to attend a Preliminary Assessment Meeting regarding future site activity. I hope to aquire knowledge about procedures of handling site remediation which might at a future time be applicable to private remediation as well as the present federal remediation.

In closing, these internships have exposed me to both research and development as well as managerial aspects of applied basic science. I have gained discipline in laboratory setting through METC, and learned an understanding of the need for management of field research through HAZWRAP. From the recognition aquired through these internships, I was offered and have acepted a position at Arizona State University for the fall. Through both internships I have obtained a professional reputation which will benefit me in aquisition of career position at a future time. I now possess a professional knowledge and attitude which will be an asset to my career.

Ms. **Lloyd**. Thank you very much. Mr. Rodriguez.

STATEMENT OF MIGUEL RODRIGUEZ-VELEZ

Mr. **Rodriguez-Velez**. My name is Miguel Rodriguez-Velez, I am currently a student at the University of Puerto Rico and will be graduating with a degree in microbiology in June.

I learned about the ORSERS program when Dr. Braulio Jimenez from the Environmental Sciences Division of Oak Ridge National Laboratory came to our campus to interview candidates and speak of the program. I applied for the program, was accepted and am now working in the Environmental Science Division with Dr. Anthony Palumbo on a project funded by the National Science Foundation.

The project is designed to determine what influences the recovery of ecosystems from disturbances such as floods. Eight artificial streams with different amounts of nutrient input and grazing pressure are being used for this study. My research project is on the recovery of the exoproteolytic activity in the artificial streams. Exoproteolytic activity is used as a measure of the activity of the bacteria in the streams.

Phytoplanktonic production or decomposition in natural waters is the major source of organic carbon and nitrogen for bacterial activity. This materials, which consists of about 85 percent proteins and peptides is of high molecular weight and can only be taken up by bacteria after exoenzymatic hydrolysis.

A very sensitive method allowing determination of the rate of exoproteolytic activity is used in the artificial streams to measure the activity of the epilithic bacteria. The method is based on the use of L-leucyl-B-naphthylamide which rise to a fluorescent product upon hydrolysis of its peptide like bond. The rate that this hydrolysis activity recovers from the disturbance is used to assess ecosystem resilience.

My research project is challenging and interesting. I have learned new techniques and procedures and this research experience has already helped me to achieve some of my future academic goals. I was accepted recently into the Doctor of Philosophy degree program of the Department of Microbiology of the Medical College of Ohio. My research experience gave me the laboratory skills and the scientific knowledge that I needed to qualify as a prospective graduated student. Working independently, and analyzing my own research discoveries has been a very challenging and interesting experience.

Since English is not my native language, this experience has helped me improve my conversational and writing skills in this language. This experience has also given me the opportunity to benefit from the knowledge of people from different parts of the United States and other countries around the world.

As a minority student, I am proud to be a representative of my Puerto Rican heritage. This experience has increased my interest in science and nourishes the hope of being able to make a contribution to the future of this country. I think that the ORSERS program has reached out to help in the development of science students in this country. It prepares better scientists and engineers who will be concerned with the progress of their society.

Muchas gracias por brindarme la oportunidad de hablarles en el dia de hoy. [Thank you very much for giving me the opportunity to speak here today.]

[The prepared statement of Mr. Rodriguez-Velez follows:]

My name is Miguel Rodriguez-Velez, I am currently a student at the University of Puerto Rico and will be graduating with a degree in Microbiology in June.

I learned about the ORSERS program when Dr. Braulio Jimenez from the Environmental Sciences Division of Oak Ridge National Laboratory came to our campus to interview candidates and speak of the program. I applied for the program, was accepted and am now working in the Environmental Science Division with Dr. Anthony Palumbo on a project funded by the National Science Foundation.

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Phytoplanktonic production or decomposition in natural waters is the major source of organic carbon and nitrogen for bacterial activity. This material which consists of about 85% proteins and peptides is of high molecular weight and can only be taken up by bacteria after exoenzymatic hydrolysis.

A very sensitive method allowing determination of the rate of exoproteolytic activity is used in the artificial streams to measure the activity of the epilithic bacteria. The method is based on the use of L-leucyl-B-naphthylamide which gives rise to a fluorescent product upon hydrolysis of its peptide like bond. The rate that this hydrolysis activity recovers from the disturbance is used to assess ecosystem resilience.

My research project is challenging and interesting. I have learned new techniques and procedures and this research experience has all ready helped me to achieve some of my future academic goals. I was accepted recently into the Doctor of Philosophy Degree Program of the Department of Microbiology of the Medical College of Ohio. My research experience gave me the laboratory skills and the scientific knowledge that I needed to qualify as a prospective graduated student. Working independently, and analyzing my own research discoveries has been very challenging and interesting experience.

Since English is not my native language, this experience has helped me improve my conversational and writing skills in this language. This experience has also given me the opportunity to benefit from the knowledge of people from different parts of the United States, and other countries around the world.

As a minority student, I am proud to be a representative of my Puerto Rican heritage. This experience has increased my interest in science and nourishes the hope of being able to make a contribution to the future of this country. I think that the ORSERS program has reached out to help in the development of science students in this country. It prepares better scientists and engineers who will be concerned with the progress of their society.

Muchas gracias por brindarme la oportunidad de hablarles en el dia de hoy. (Thank you very much for giving me the opportunity to speak here today.)

Ms. **Lloyd**. Thank you. Mr. Schiff.

Mr. **Schiff**. Thank you, Madam Chair, for the privilege of going first. I did request to do so which is out of our ordinary order, for a couple of reasons.

First Ms. Ethridge, I want to tell you, you do not owe anybody an apology for anything. I do not think in this program we believe that everyone admitted has to turn out to be a NASA rocket scientist. By the way you obviously have the talent to do that or you would not be in the program. But you do not owe anyone an apology for having other interests.

I am a social scientist myself and some of the physical scientists ridicule that term "scientist" when I use it.

There are other reasons for promoting scientific education. One is the more the general populace knows, the more the information is spread out and around and so forth. I do not know if you heard a witness we had earlier talking about stereotyping women and minorities, especially women, in science that said the first thing they want to have when a little girl comes home from elementary school and says to her mother, I do not know how to do my math homework, we do not want the mother to say go ask your father. So you see, you have already crossed that line right there.

Second of all, you said the magic words to me. You said gee, I thought this summer I could get a job in mathematics faster than I could get a job in philosophy or religion. The reason in my mind we are promoting scientific knowledge is not just for science's sake, but I think that is where the future jobs and employment are. If you are able to get a job as a novelist I think that is wonderful, but the day could come in your future where whether that is your primary interest or not, you may need to be working in the scientific community.

You owe nobody an apology for anything.

The other very brief thing, Senor Rodriguez, I have the opposite situation, I am originally an English speaker who moved to an area of which the Hispanic population is 50 percent of the State. So you needed to learn English, I needed to learn to speak Spanish, so I certainly understand what you said. Muchas gracias for that.

I just have one area of questions. I am not familiar with the program and I would just like to ask briefly did you compete with other students to be in this program? Just briefly any one of you—I assume it is the same program more or less, although in different fields. With whom did you have to compete and how did you get selected?

Ms. **Kowalski**. Well, I do not know if it is the same program as them, the Oak Ridge Associated Universities internship program, which I applied for, we filled out an application and we submitted our academic records and recommendations from faculty members or community members for the position. We also briefly enclosed a statement of goals, which was also included in the application. So basically it was a recommendation and academic standing that got us the position.

Mr. **Schiff**. Do you have any idea, Ms. Kowalski, how many—for the position you got, how much competition was there, how many other students do you believe applied that were not selected?

Ms. **Kowalski**. For my present position?

Mr. **Schiff**. Yes.

Ms. **Kowalski**. There was five other applicants, and I am a recent graduate. I graduated with my degree in December but to be a graduate student and be accepted that quickly is pretty phenomenal. In my previous position I believe there was 25 other applicants.

Mr. **Schiff**. For how many positions?

Ms. **Kowalski**. For one.

Mr. **Schiff**. For one. So you had to be the best of 25 to be selected.

Ms. **Kowalski**. Yes, sir.

Mr. **Schiff**. It is actually a job as well as—I am trying to picture, it is a job, it is not just an educational grant? You are supposed to, except at the very beginning as described by Ms. Ethridge where you are just trying to learn, you know, where the hallways are, you are expected to perform and do something in the programs?

Ms. **Kowalski**. Yes, sir. We have—well presently in my position, I am responsible for several jobs that I have to do and I am given chores that I have to do for different people, and it is my responsibility to find out how they want them done and present them in a manner to which they want.

Mr. **Schiff**. And your specialty is geology, is that correct? That is what we have listed here.

Ms. **Kowalski**. Yes, sir, I am going to be—I hope to obtain my Master's degree in hydrogeochemistry, which is a groundwater field.

Mr. **Schiff**. Madam Chair, I just want to conclude by saying that first of all if any of these three young people want to go on to become NASA rocket scientists, that is okay with me too. But I also want to observe, you know, when we are talking about science, we have talked an awful lot about physics and that is maybe because Dr. Trivelpiece was our first witness. And I want to point out that I am glad that mathematics and geology and microbiology are getting into the scientific subject matter also.

Ms. **Lloyd**. Thank you, Mr. Schiff. And I want to apologize for not letting you lead out earlier. I got into it and it was not my intention, so I publicly apologize to you.

How did you students find out about the programs?

Ms. **Ethridge**. I have lived in Oak Ridge all my life, so I basically—well not all my life, but most of it.

Ms. **Lloyd**. You grew up with the program?

Ms. **Ethridge**. Right. My dad worked in the plant, so I—but to be honest, I did not know much about ORAU. I know that at Roanoke College in the math department we have a bulletin board and we do have pamphlets on it, but I am the only student I have ever seen to even look at the bulletin board, so I do not know how many others actually know about it. And I only knew about it because I live in Oak Ridge.

Ms. **Lloyd**. Well Jennifer, let me say to you that even though at this time you may not think that is the area you would like to go, you never know when fate may change your lifestyle. I was an English major and who thought that I would end up chairing an Energy Subcommittee. And I have had to dig, I have had to study hard, it does not come easy. But there are very few of us on this committee that do have the true scientific background and I would say to you that ten years from now, your needs and your path in life may change, so I hope you will consider that as well.

Teresa, do you feel that your educational background helped you participate in the programs?

Ms. Kowalski. Yes.

Ms. Lloyd. You have made a lot of progress in a short time.

Ms. Kowalski. Thank you. Yes, that and the fact that I wanted four years before I came back to college. It took me a long time to decide if and what I wanted to study and I needed a spark to set me off in the right direction. I was originally a math and computer science major until I sat in on one of my sister's geology classes and decided that this is definitely where I wanted to start. So my education has a lot to do with what I do. I like a little bit of everything, so I studied a little bit of everything. My background is real diverse, so it is just a matter of interest.

Ms. Lloyd. Had any of you participated in DOE programs previous to this?

Ms. Kowalski. Just the two.

Ms. Lloyd. Mr. Rodriguez, have you discussed this program with any of your peers?

Mr. Rodriguez-Velez. You mean in my country?

Ms. Lloyd. Yes.

Mr. Rodriguez-Velez. Yes. In fact there are some friends of mine that are waiting to find more information about the program and they are encouraged to apply and they are thinking to apply for next fall. It is nice because I think there are many potential students on our campus and many campuses in Puerto Rico, I think that could be in other states, that maybe if one of us tell them about the program, that they really get encouraged and they can really find a good experience through these programs. Because I think that they gave us the chance to really develop our mind as scientists.

For example, in my case, this really encouraged me to continue studying for my Ph.D. and helped me to find out really what I wanted to do in science. It helped me a lot.

Ms. Lloyd. Do you know of any other programs other than this one that you were selected for?

Mr. Rodriguez-Velez. Well in Puerto Rico, I participated in a program that is similar, it is called Puerto Rico Research Center for Science and Engineering, a summer research program. There we do not have the state of the art technology and equipment that you have here, and that is why I think it is really important, the experience that students can get from the national labs.

Ms. Lloyd. Thank you very much. We thank all of you. You were excellent witnesses and we certainly wish you the best.

This concludes this hearing. We will be—I think Mr. Schiff and I agreed that this would be the beginning of hearings that we would like to involve our Committee in, and I just must say that I do not know a more dedicated member of our Committee that works harder than Congressman Schiff. And again, my appreciation for you being here in Chattanooga.

I would also like to thank the staff, Mr. Murray and Ms. Smith and Ms. Rising for their excellent help, our recorder, and also I would like to thank my Chattanooga staff for their help.

Unless there is further comment, we do thank all of you—Mr. Schiff?

Mr. **Schiff**. Nothing.

Ms. **Lloyd**. We thank all of you, and if there is no further comment, the subcommittee stands adjourned.

[Whereupon, at 3:48 p.m., the Subcommittee was adjourned.]